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EVALUATION OF THE EFFECTIVENESS OF THE STORAGE AND DISTRIBUTION ENTRY-LEVEL COMPUTER-BASED TRAINING (CBT) PROGRAM

THESIS

Mark A. Donavon, Captain, USAF

Michael E. Guy, Captain, USAF

AFIT/GLM/LSM/90S-14

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EVALUATION OF THE EFFECTIVENESS OF THE STORAGE AND DISTRIBUTION ENTRY-LEVEL COMPUTER-BASED TRAINING (CBT) PROGRAM

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

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September 1990

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Preface

Although this project was fairly simple by design, the literature review and data collection aspects proved very demanding and time consuming. We acknowledge that this research was more than a two man effort. The knowledge, ideas, and expertise of many people are represented throughout this thesis. They have helped us to create a document which we are proud to have our names on.

We are deeply indebted to our sponsor, Lt Col Tim Peterson, AFLMC, who gave us the idea for this study, and was invaluable as a primary source of information and support. Further, we would like to thank our advisor, Lt Col Fred Westfall for his patience, assistance, and understanding throughout the thesis process.

We are deeply indebted to Capt Steve Brown and the people at the 3440th TTC, Lowry AFB, CO, who went out of their way to provide critical logistics support. Tsgt James Banks, NCOIC of the Storage and Issue Section deserves recognition for allowing us free access to his warehouse.

Although we have had a great deal of help along the way, we are in complete agreement that our biggest supporters, helpers, and constructive critics have been our wives, Jean Donavon and Rene´ Guy. Their many contributions often went without thanks, but never went unnoticed. To them we now say "thank you".

Mark A. Donavon
Michael E. Guy

Table of Contents

List of Figures

List of Tables

AFIT/GLM/LSM/90S-14

Abstract

Currently, there is no in-residence technical training course for Supply warehousemen, AFSC 645X1. Therefore, base level supervisors and trainers are responsible to provide the initial technical training for direct duty assigned airmen in the 645X1 AFSC. Given the absence of a formal technical training course, most base level supply squadrons use the 64531 Career Development Course (text) to train their direct duty assigned warehousemen. The purpose of this study was to conduct an experiment which compares the effectiveness of the Computer-Based Training (CBT) computer program with ~~the~~ commonly used text training, using a CBT module which was developed by the new supply CBT development team, located at Lowry AFB, CO. The results of this ~~study~~ thesis have shown that when used properly, CBT can increase the amount of learning which takes place, increase the ability of trainees to perform the tasks for which they are trained, and reduce total training time. This research directly supports the Air Forces´ continued use of CBT for the initial training of supply warehousemen, and further suggests that CBT may be a suitable technique for other Air Force training needs.

EVALUATION OF THE EFFECTIVENESS OF THE STORAGE AND DISTRIBUTION ENTRY-LEVEL COMPUTER-BASED TRAINING (CBT) PROGRAM

I. Introduction

General Issue

In November, 1985 HQ USAF/DPPE and the Air Training Command (ATC) made a joint decision to eliminate the initial Supply Materiel, Storage and Distribution Specialist Training Course, Air Force Specialty Code (AFSC) 645X1, at the 3440th Technical Training Center (TTC), Lowry Air Force Base, Colorado. The last students graduated from this course in September 1986 (46: Attachment 6-4). New Airmen with the 645X1 AFSC are now sent Direct Duty Assignment (DDA) from basic training to base level supply squadrons, and the initial training burden is now being placed on the base supply training section and the trainees' supervisors (46: Attachment 6-5).

In November 1988, ATC and the Air Force Logistics Management Center (AFLMC) created a CBT development office at the 3440th TTC. The goal of this office is to develop CBT programs which will provide the initial training for supply warehousemen, AFSC 645X1. The purpose of the CBT programs is to teach DDA Air Force supply personnel (645X1) basic supply-related procedures at the base level. The Storage and Distribution Entry-Level CBT Program, which is

used in this study, was scheduled for completion in December 1989 (46: Attachment 6-6). Approximately 20 other supply related programs (lessons) are presently undergoing final revisions, and should be released to the field by October 1990.

Specific Problem

Research should be conducted to determine the effectiveness of the Materiel, Storage and Distribution Entry-Level CBT programs before they are released for use throughout the Air Force. The term "effectiveness" refers to the degree to which learning takes place, the time required to complete the training, and the ability to perform an actual task.

Hypothesis

The Storage and Distribution Entry-Level CBT Program is a more effective training tool for training DDA 645X1 personnel than is the 64531 Career Development Course (CDC).

Investigative Questions

In order to better determine whether to reject or accept the hypothesis, research must be conducted to answer the following investigative questions:

1. What are the present base level training methods being used to train DDA supply warehousemen, AFSC 645X1?

2. Do the AFSC 645X0 experimental test subjects represent a statistically similar population when compared to newly assigned DDA 645X1s?

3. Are there any significant differences between the test subjects' AQE scores from the three experimental treatments?

4. Do the test subjects learn more, as measured by a post-test, when trained using CBT versus CDCs?

5. Do the subjects perform the actual task better when trained using CBT?

6. Is training time reduced when the test subjects are trained using CBT?

7. Does computer experience and education affect the student's comprehension of the material presented via CBT?

Terms Defined

The following terms are defined for reader clarity.

1. AFSC 645X1 - Materiel, Storage and Distribution Specialist. Individual is responsible for the accurate and timely receipt, storage, inventory, issue, delivery, and shipment of property (21: Attachment 37).

2. AFSC 645X0 - Inventory Management Specialist. Individual computes requirements, allowances, and performs research on supplies and equipment. Individual is also responsible for inventory stock control (21: Attachment 37).

3. Computer Assisted Instruction (CAI) - This term is used when a computer is utilized to administer training to

users. This training should provide interaction between the user and the computer (37:14).

4. Computer Managed Instruction (CMI) - This term is used when a trainer uses the computer to plan training programs, record student performance, or assign lessons (56).

5. Computer Based Training (CBT) - Using a computer to implement and manage training (37:17). The term CBT will be used throughout this thesis to refer to any training programs utilizing a computer.

Background

The use of CBT has become commonplace in the private sector. A survey of 200 randomly selected industrial training managers conducted by Kearsley and Hillelsohn showed that forty-two percent of managers were using computers in training activities and another forty-one percent were planning on implementing computers in training (42:22). CBT is also used extensively in the public sector. Dr. Alfred Bork, Director of the Educational Technology Center at the University of California, predicts that "computers will comprise the dominate delivery system in education for almost all age levels in most subject areas" over the next 25 years (11:4). Limited use of CBT has taken place in the Armed Forces. The Navy has taken the lead in the use of CBT. At the present time, approximately 12.6 percent of the Navy's courses with large student enrollment

use some type of CBT, and entry level courses use CBT programs much more often than advanced courses (70:16).

Many studies have been conducted to investigate the learning and cost effectiveness of CBT. In the majority of these experiments, CBT provided positive results in terms of learning, and in cost savings associated with the reduction in training time and better utilization of training personnel (20:42; 28:64; 29:14; 70:40). Even though CBT appears to be very effective in many training situations, CBT should not be forced into an area of training where it may not be applicable, or when other techniques may be more suitable. A need should be identified before CBT is introduced. CBT should only be implemented when the reasons why the computer will help training can be identified (70:20). In most instances, CBT should not be used as a stand alone training program. "CBT should be used as an ancillary tool or aid for the instructor where it can make a significant contribution rather than replacing the instructor" (70:20).

In September 1986, the last students graduated from the 645X1 Initial Materiel, Storage and Distribution Apprentice Training Course at Lowry AFB. Since its elimination, no course has been developed to fill this training void (46:Attachment 6-4). The results of eliminating this training course are:

1. Large numbers of untrained personnel have been assigned directly to the field.

2. A heavy training requirement has been inherited by base supply training sections and the trainees´ supervisors.

3. The large influx of untrained personnel has reduced trainee competency levels, negatively effecting mission accomplishment (46: Attachment 6-5).

In October 1988, approval was granted for ATC and the AFLMC to develop and produce CBT lessons for initial base level training for DDA 645X1 personnel. Development of these lessons began in November 1988. The cost of producing the lessons was estimated at $300,000, which was to be spread over the 18 month development period (46: Attachment 6-6). The lessons were developed as an on-the-job training (OJT) enhancement program (46:1).

At the 22-23 February 1989 Supply, Computer-Based Training Tiger Team Meeting, Lt Col Tim O. Peterson, then Director of Supply, AFLMC, referenced an October 1988 study of the benefits Fortune 1000 Companies realized using CBT. These benefits are (46: Attachment 6-19):

1. Improved training availability
2. Individualized training
3. More cost-effective
4. Frees supervisors from routine training
5. Improves transfer of knowledge to the task

The widespread use of CBT in the private sector, education, and in a limited scope in the military, indicates CBT is a valuable medium in some training environments. Therefore, the potential use of CBT should be explored carefully in order to bolster training effectiveness. Since the elimination of the 645X1 Initial Materiel, Storage and Distribution training course at Lowry AFB has created a training void, the use of CBT to fill this void should be thoroughly evaluated.

Before implementing a CBT training module to fill the 645X1 training void, the CBT should be tested to insure that it will supply effective and efficient training. The experimental design used in this thesis objectively evaluates the effectiveness of the CBT program developed and produced by ATC and AFLMC.

Scope

Research was performed to satisfy two objectives. The first objective was to provide the reader with an understanding of how CBT evolved, the intricacies involved when applying CBT to a training situation, the current and future status of CBT development in the Air Force, and current learning theory. The second objective was to design an experiment which will determine how effective CBT is compared to another currently used training method.

The first objective will be satisfied through the literature review. Sources consist of periodicals,

technical journals, telephone interviews, personal interviews, government reports, theses, dissertations, professional conference seminars, and Air Force Regulations. A brief history of CBT is presented in order to provide an understanding of how CBT evolved, and the advantages and disadvantages of implementing CBT for instruction of personnel will be investigated. The results of previous experiments will be studied to determine if CBT is useful in a large variety of training situations or applicable only to narrowly defined training situations. Research also includes the exploration of the traditional training methods used in the training environment. The authoring system used to develop the Storage and Distribution Entry-Level Training Program (QUEST, version 3.0) will be described in order to determine the reasons why ATC and AFLMC chose to use QUEST versus other available systems. Current theories and principles of learning are addressed to give the reader an understanding of the logic behind CBT development. Also, the concept of training is discussed to provide the reader with an appreciation of the importance of training and the need to develop training which "transfers" easily to the workplace.

In order to satisfy the second objective, research was conducted to determine the best experimental design in order to ascertain if the supply CBT program is more effective than current training methods. The experimental design

compares the effectiveness of the 645X1 CDC, which is currently being used by most base level supply squadrons, and the Storage and Distribution Entry-Level CBT Program as administered to 645X0 personnel in Entry-Level Training at Lowry AFB.

Specific conclusions about this research project will be made in reference to the effectiveness of the Entry-Level Storage and Issue CBT lesson, used for the initial training of DDA 645X1 personnel. The results should be generalizable to all CBT lessons created at Lowry AFB, since the other supply-related lessons were created and developed using the same learning concepts and instructional techniques.

Limitations of the Study

All research projects possess limitations in one form or another. Since researchers cannot completely control all of the variables affecting their research, it is important that limiting factors which affect the research be identified and understood. The following limitations are identified as having a possible effect on this research project:

1. Since supply warehousemen, AFSC 645X1, are sent directly from basic training to their duty assignments, it is very difficult to get a large number of newly assigned 645X1s together for experimental purposes. Therefore, entry-level supply operations personnel, AFSC 645X0, were used as test subjects for this research.

The extent of this limitation will be determined by comparing the Airman Qualification Examination (AQE) test scores in the general category of the 645X0 experimental subjects to those of 645X1 personnel. These AQE scores will be obtained from the Human Resources Laboratory Data Bank (HRLDB), located at Brooks Air Force Base, Texas.

2. The relatively small total sample size may not provide data which is truly indicative of the 645X1 population. During the early phases of this research, the 3440th TTC had 1-3 Basic Supply, AFSC 645X0, classes begin each week with class sizes ranging from 12-25 students. Since data-gathering trips were scheduled during weeks when 3 classes were scheduled to begin, an estimated 40-75 experimental subjects could be tested during one week. Since the authors planned to make 4 experimental trips to Lowry AFB, a total sample size of 160-300 subjects was originally projected.

However, recent cutbacks in the number and size of classes have resulted in a much smaller total sample size. Currently, an average of 1 new class begins each week, with 7-12 students in each class. Given that the authors made 4 experimental trips to Lowry AFB, a total sample size of 28-48 subjects was expected (a total of 49 subjects was actually obtained). Therefore, the authors were forced to accept a total sample size which was much smaller than originally planned.

3. Coordination and planning at Lowry AFB for the data gathering trips was performed for the authors by a point of contact (POC) at Lowry AFB. The POC was responsible for contacting and coordinating with several organizations at Lowry AFB, to prepare for the experimentation. Coordinating through the POC resulted in some problems which the authors could have handled had they been at Lowry AFB prior to the initial experimentation. It is important to note that these problems did not arise due to the lack of effort on the part of the POC, but resulted from a lack of understanding of the intricacies and complexities of this experiment.

4. The post-test is another possible limiting factor. It was designed to test the specific objectives used by the CBT module, which was used in this experiment. The text module includes excerpts from the 64531 CDC, which correspond with these same objectives. Therefore, it is possible that the post-test may favor the test subjects in the CBT treatment. To better analyze this possible limiting factor, a task analysis is incorporated into the experimental design. The task analysis is a neutral measurement tool which does not favor either treatment. It simply measures the ability of the test subjects to perform the task of properly warehousing a piece of property.

5. Another possible limitation, which may effect the results of this study, is that each of the authors traveled to Lowry AFB, and performed this experiment on different

occasions. Therefore, there is a possibility that the authors may have unintentionally given their respective test subjects a different set of expectations based on differences in their personal interactions. Obviously, it would be ideal for the same person to present the experiment to the test subjects each time, ensuring that interactions with each treatment were always identical.

Since it was impossible for only one person to travel to Lowry AFB on four separate occasions, the authors went to great lengths to insure that their interactions with the test subjects were identical. As you will see in Chapter IV, the interactions with the test subjects were carefully planned, to the point of using written introductions.

II. Literature Review

Overview

This literature review will present a brief history of CBT along with the advantages and disadvantages of using CBT in training situations. The results of experiments on CBT programs in various training environments will be presented to determine if CBT is effective in different training environments. Also, the current and future status of CBT development in the Air Force will be described, as will the traditional training methods used in various training environments, and the current theories and concepts of learning. Finally, the features and capabilities of the QUEST authoring system used to produce the Entry-Level Storage and Issue CBT program will be highlighted.

History of CBT

This section of the literature review provides a brief description of the historical development of CBT. This background will provide the reader with valuable background information, and an understanding of how and why CBT was developed.

In 1926, Sidney Pressey, an Ohio State University professor, developed a machine named the "Pressey Testing Machine". This machine taught and tested students (61:103).

> A student studied the subject in the usual way and then turned to the machine. The machine directed the student to a first item on a multiple-choice test, and the student made a choice by pressing a numbered key. If the choice was right, the machine moved on to the

> next item; if the choice was wrong, the student pressed another key. When the student went through the test a second time, the machine stopped only on those items on which the student's first choice had been wrong. (61:103;104)

The next major innovation in the use of computers in education and training occurred in the 1950s. B. F. Skinner, professor emeritus from Harvard University, developed a machine that was an improvement over the earlier machines; Skinners' machine taught the students the material. The items on the testing portion were sequentially arranged, so that if the student answered the question correctly in the first frame he was better prepared to move to the next question (37:9). Skinners' machine was fashioned directly after his theory of learning.

> Skinner's analysis of instruction assumes that motivation must be present, that the students must make a response, and that this response needs to have consequences which are reinforcing. The increased specificity of Skinner's suggestions center around the principle of stimulus control. (3:18)

The interaction between the student and the computer was termed "computer-based interaction". Until this point in time, CAI was seen as possibly replacing teachers. But in the 1960s, International Business Machines (IBM) declared that these systems were a support tool for the teacher to use, not a replacement for teachers (37:11). In the early 1960s, IBM developed Coursewriter I, the CAI authoring language. Soon after the introduction of Coursewriter I, many other authoring systems were introduced into the market. The availability of authoring systems and the

increased capabilities of computers in the mid-1970s led many educators to believe CAI would play a large role in the future of education (6:1). However, others did not agree and were very skeptical; they believed that CAI could not motivate and provide necessary interaction between students and teachers. Critics said computers could never come close to replacing teachers. Now, fifteen years later, the same people are going into classrooms and observing how computers have revolutionized learning in the classroom (32:167).

In 1980, approximately 22,000 public schools provided CAI, which represents nearly 50 percent of all secondary schools and 14 percent of all elementary schools (6:1). In 1983, there were 291,000 computers available for instructional use in the public school system. There is no indication that the upward trend in the use of computer instruction will decline in the future (67:62).

Methodology/Design of CBT

Perhaps the greatest strength of CBT is the flexibility it can provide trainers. CBT can be used to meet many training objectives. In order to meet varying objectives different CBT methodologies need to be utilized. The different methodologies consist of drill and practice, tutorials, simulations, and tests (37:17). This section of the literature review will investigate the structure and logic behind each of the aforementioned CBT methodologies.

Drill and Practice. The CBT drill and practice method is most effective in the training of routine skills. Drill and practice presents the item more than once in order to increase fluency, speed, and retention of the subject matter. If the student answers incorrectly, the item will be presented more often. This method should be used only to reinforce learning of material already presented to the student (37:18; 68:43-44).

There are five steps in the drill and practice procedure (37:18; 68:46):

1. An introductory page is presented to the student. The page should consist of a statement of learning objectives, and directions on how to do the lesson.

2. The student selects an item. The selection can be a question, problem, or some other form of exercise.

3. The student formulates a response and inputs the response using the computer keyboard or other input device.

4. The program judges the response.

5. The program provides feedback to the student.

The entire 5 step procedure is repeated until the student decides to quit, or the student has satisfied the requirements of the Drill and Practice program (37:18).

Tutorials. A tutorial is very similar to drill and practice, but unlike drill and practice the tutorial can stand alone as a CBT program. The tutorial presents new information to the student and then evaluates the student's

comprehension of the material (37:19). The tutorial also provides the students with an opportunity to practice the skills that were taught (37:19). Tutorials should be organized so the student can complete them in 30-60 minutes. If the student completes the lesson in less than 30 minutes, he may consider the lesson a waste of time. If it takes the student more than 60 minutes to complete the lesson, he may become bored and disinterested (26:5).

The following list illustrates how a tutorial program is structured (37:19; 26:6):

1. The student is presented with introductory material.

2. The student is presented with information needed to learn the skill.

3. The student is then directed to perform some action related to the information presented, such as, answering a question.

4. The student's response is then judged.

5. The program provides the student with feedback or remediation in accordance with the response.

If, after the initial response, the student chooses to move ahead or receive enrichment material, the above steps must be repeated again. When all the material is covered and the student has answered enough questions correctly to satisfy the criteria of the program, he is informed of the

successful completion of the lesson and will be given the choice to review or terminate the lesson (37:19).

Computer-Based Tests. Computer-based tests usually only present test questions once unless the programmer desires to provide the student the opportunity to review answers prior to test completion (37:23). Feedback on performance is provided to the student only after the completion of the test. However, if the test is being used as a pre-test instrument, feedback can be provided after each response (37:23; 27).

The following are the steps a CBT test must follow to accurately determine student comprehension (37:23-24):

1. The student is presented introductory material (directions for taking the test).

2. A question is asked and the student provides a response.

3. The response is evaluated.

4. A practice-test program will then provide feedback. If the test is being used exclusively for assessment, the next question will be asked.

5. After all of the questions have been completed, the student is provided with feedback.

Computer-based tests can accurately determine comprehension of material only if questions are formulated with the correct content, and presented in a clear and logical manner (27).

Simulation. Like tutorials, simulations can teach basic concepts and principles. However, simulations go a step further into the teaching of problem solving (37:20). Simulation programs provide the student an opportunity to experiment with a realistic situation when it would normally be too expensive or dangerous to do so (37:20).

The following steps are involved in a simulation program:

1. The student is presented with concise introductory material in order to correctly operate the program.

2. The phenomenon (person, object, or situation) is pictorially or descriptively presented to the student.

3. The student takes an action concerning the phenomenon.

4. As a result of the student's action, the system in which the phenomenon exists is changed.

5. These changes in the system bring about changes in the phenomenon, and are illustrated to the student graphically or descriptively.

The above steps are repeated until the student decides to terminate the simulation or the simulation has been completed successfully or unsuccessfully. When the simulation has been completed, the student receives final results of his actions (37:21). The success of a simulation program primarily depends on how well the simulation represents the actual phenomenon (37:21).

Advantages and Disadvantages of CBT

In order to determine if CBT can be used in a training situation, one should consider the advantages and disadvantages of CBT. The following lists of some advantages and disadvantages of CBT provide a compilation of the opinions of noted academics and CBT experts.

Advantages.

1. The CBT process is interactive. It provides the student with an interactive role in the training process (7:85).

2. CBT is flexible and consistent, allowing trainees to learn at their own pace (7:85).

3. The trainee receives immediate feedback on his performance during the actual training process (7:85).

4. CBT can provide the trainee with a dynamic display of material through the use of computer graphics (31:216).

5. CBT can provide training for large numbers of students who need frequent training, therefore reducing the need for a trainer to repeatedly present the same material (31:216).

6. CBT can be used to supplement limited instructor resources (70:20).

7. CBT can provide a reduction in the total time needed for training (up to 30 percent), which can provide a complementary reduction in training costs (7:85).

Disadvantages.

1. The amount of contact a student has with people is reduced by the amount of time he spends using the computer. Therefore, personal interaction skills may suffer (2:2).

2. Some people may learn better in other training environments, such as classroom instruction or self-study (7:85).

3. CBT is of little value when the training goals must be changed frequently (31:26).

4. CBT software may be unreliable (7:35).

5. CBT is a poor training medium for presenting large amounts of text (31:26).

6. The initial costs of implementing CBT can be very high. Computers and software must be purchased before any training can take place (42:22).

7. Limited amounts of computer equipment (hardware) may lead to scheduling problems (7:85).

Obviously, all of the advantages and disadvantages will not apply to every organization. For example, an organization which already has a vast supply of computer equipment need not be concerned with the expense of the resources. However, it is important to understand that the decision to use CBT must be made by analyzing the advantages and disadvantages which may apply to an organization.

CBT Experiments

Three examples of experiments which test the effectiveness of CBT in training situations are presented in this section of the literature review. Each example is drawn from a separate environment (academic, industrial, and public) to illustrate how CBT can be successful in various environments.

Academic. A study was conducted at Worcester Polytechnic Institute, Worcester, Massachusetts in 1986 to evaluate the effectiveness of a CBT program called PasLab. PasLab is a CBT program for instruction in an initial Pascal computer language course (28:61).

Samples of the students enrolled in the initial PasLab course during terms 1984 A and B, received instruction in the traditional Pascal course. Students in terms 1985 A and B received instruction utilizing PasLab (28:62).

The percentage of students able to pass the Pascal course in 1984 A and B was 76 percent, while 89 percent of the students in 1985 A and B who used PasLab passed the introductory course. This study showed that not only did the use of PasLab increase the number of students who passed the Pascal course, it also encouraged students to enroll in more advanced computer language courses (28:63).

Industrial. A CBT program was developed for asceptic-packaging filler operation (for small drink boxes) training at Houston based Coca-Cola Foods. The program consisted of

seven, 1 hour long, training modules using graphics and picture designation design. The study measured the performance of employees who received the CBT program from October 1985 to February 1986. Data was gathered from four U.S. plants; three using CBT and the fourth serving as a control group (20:41).

The study revealed that the CBT had a significant positive effect on operating efficiency (1.3 percent). The study also showed that the plant's could expect a minimum of $530,000 to a maximum of $1,130,000 in net savings over the next five years due to the possible increase in efficiency as a result of training with the CBT program (20:44). This study shows it is possible to successfully implement CBT for the training of employees in an industrial situation.

Public Sector. A study conducted by the Federal Bureau of Investigation (FBI) compared computer-based instruction to a highly interactive lecture. The subjects of the study were 64 new trainees at the FBI Academy. The first group of subjects were taught a block of training using a highly interactive lecture. The second group received the same block of training through computer-based instruction. A third group received the same training block using lecture and computer-based instruction. The test instrument used was a six item multiple choice test authored by experts in the field of investigation (64:2).

The following are the results of the experiment:

> The results support that computer-based instruction can be more effective in fostering student learning. Students exposed to the subject matter only through CBI scored significantly higher on a knowledge test than did students who were exposed to the same subject matter through only lecture. As one might expect, students who were exposed to the subject matter through both instruction methods also scored significantly higher than did those who only attended the lecture. However, the Lecture/CBT group did not score significantly higher than their CBI counterparts. (64:8)

The results of this study show that computer-based instruction is a powerful tool to teach the process of decision making skills required for Special Agents in the FBI (64:10).

Status of CBT Development in the Air Force

The Air Force Supply community began developing CBT in 1988. This drive for CBT development was spawned by a desperate need to provide some type of standard training to DDA supply warehousemen (54). This section describes the current status of CBT development in the supply career field, and presents some thoughts on the future of CBT from a strategic perspective.

Current Status. With USAF/LEYS as the functional OPR, the AFLMC and the 3440th TTC are working together to design, develop, and distribute CBT for use within the Air Force supply community. Their individual and joint responsibilities are defined in a memorandum of agreement (MOA) (55).

The bulk of their efforts has been geared towards developing training modules for DDA supply warehousemen, AFSC 645X1. As of this writing, the 3440th TTC has 20 lessons nearing completion, which are scheduled for release before the end of calendar 1990. These lessons include general information covering the Air Force Supply System, the Materiel, Storage and Distribution Branch, and basic principles of warehousing (57). USAF/LEYS also provided a list of subjects which they think should be developed using CBT (38). Figure 1 provides a list of these topics.

The 3440th TTC is authorized 12 temporary manning positions which were originally scheduled to expire on 1 July 1990, but were extended until 1 July 1991 (41).

Training the personnel who work in the CBT development office presents a multi-faceted problem because these people perform two of the three essential functions of a good CBT development team; program developers and subject matter experts (57).

To become proficient CBT developers, they must first learn the technical skills required to use the authoring system. Once they learn how to use the features of the authoring system, they must then learn the fundamentals of defining training objectives, identifying important material to include in the lessons, and presenting information according to accepted learning theory. All of these steps are critical to the development of quality CBT (55).

Lessons/subjects	Type of Training
Supply Customer Training	Ancillary
Supply Inspector Course	Proficiency
Funds Management	Augment resident
Research Process	Proficiency/upgrade
Systems Analyst (5 level)	Proficiency/upgrade
Base Civil Eng. Logistics	Replace resident
Material Control (Generic)	Proficiency
MICAP Management	Proficiency
War Readiness Spares Mgt.	Proficiency
Mobility Program Management	Proficiency
Base Supply Trainer	Replace resident
Combat Supply System	Proficiency
Stock Control Functions	Proficiency
Base Contracting Interface	Proficiency
TAR Program	Proficiency
Supply Analysis (64570)	Proficiency
Repair Cycle Management	Proficiency
Supply Executive Course	Augment resident
Health Hazard Material Mgt.	Proficiency
Reports and Listings	Proficiency
Equipment Management (AFEMS)	Proficiency
Ancillary Training (supply)	Replace base level
Supply Weapons Management	Proficiency
Delinquent Document Mgt.	Proficiency
Reject Program Management	Proficiency
Computer/Micro Operation	Proficiency
Data Trans (SIFS,BLMS,etc.)	Proficiency
Post-post Procedures & Ops.	Proficiency
Inquiry Selection	Proficiency
How to Use AFM 67-1	Proficiency
Stock Number Characteristics	Proficiency
CDC's (645XX)	Replacement
Precious Metals Recovery	Replace ancillary

Figure 1. Potential Topics for Supply Related CBT (38)

In addition to the need for program developers and subject matter experts, a knowledge engineer comprises the third important ingredient of a good CBT development team. A knowledge engineer is defined as someone who has an understanding of learning theory, and who can integrate the

learning concepts with the requisite material during the CBT development process. In this capacity, the knowledge engineer must be able to verbalize and make understandable, the learning concepts and theories which apply to the training situation (55). Appendix A contains a copy of an article written by the current supply career field knowledge engineer. This article thoroughly describes the applicable learning theory for the training of 645X1s, and further explains how this learning theory should be integrated into the actual design of the CBT.

According to the existing MOA, Lt Col Peterson, AFLMC, is the approved knowledge engineer for the Air Force Supply CBT development program. This MOA gives him the authority to accept, reject, or change any of the CBT modules before release. As a result, no CBT modules are released to the field without his consent.

The knowledge engineer has been a source of information and a "sounding board" for the CBT developers since the inception of the CBT development program. He is responsible for giving the developers a basic foundation in learning theory, which will help them to develop quality CBT. Also, he reviews in-work CBT modules to identify shortfalls, suggest changes, and increase the proficiency level of the CBT developers (55).

Future Plans. There is not an established plan or policy which sets the course for the future direction of CBT

development in the supply career field, or in the Air Force for that matter. In an effort to determine the future of CBT, some of the individuals who are involved in the development of CBT at a strategic level were interviewed.

In a Nov 89 message to HQ ATC, USAF/LEYS stated:

> We see CBT as having a great potential to effect productivity gains in the areas of supply (AFR 50-10) customer training (ancillary), proficiency training, and complementary or supplementary technical training...We believe this effort is just the beginning of innovative ways to improve training methods. (38)

USAF/LEYS stated that converting supply customer training to CBT will save approximately 200,000 man hours per year, which customers now spend in supply classrooms. In addition to saving supply customers time, USAF/LEYS sees many other benefits which CBT could provide. Some of these are (38):

1. Manpower savings in supply training sections

2. Reduce or alleviate training shortfalls

3. Reduce enroute training requirements or denials for personnel going to short tour areas or on short notice assignments

4. Reduce and augment mobile training teams

5. Replace previously cancelled resident courses

6. Complement, supplement, and augment current resident courses

7. Replace low density (attendance) resident courses

USAF/LEYS fully supports the development of a permanent CBT development branch as a part of the 3440th TTC. They

believe this branch should consist of 1 supply CMSgt, AFSC 64500 (CBT development manager), 12 supply subject matter experts (CBT developers/maintainers), and 2 personnel from AFSC 70/75XXX (duplication and distribution of CBT software). The 12 subject matter experts should consist of 7 personnel in AFSC 645X0, 2 personnel in AFSC 645X1, and 3 personnel in AFSC 645X2. Further, the lowest rank for any of these 12 people should be SSgt (38).

According to the Assistant Division Chief for Training and Systems Development, HQ ATC, ATC acknowledges that in an era of diminishing resources, there is a need to develop and use new training technologies such as CBT. Although ATC has not provided any policy or guidance at this time, the command is in the process of identifying concepts and principles which it will include in future policy. ATC does not expect CBT to replace existing technical training instructors, but rather, to enhance existing training courses by including blocks of CBT when and where appropriate (9).

According to the Supply Training Staff Officer, HQ ATC, ATC may offer to relocate six of their own permanent manning positions to the CBT development office. In turn, the six remaining positions in this office would be filled using permanent manning positions gained from the major commands. However, no official proposal has been made (41).

Lt Col Peterson, the assigned "knowledge engineer" for supply-related CBT, is an active proponent of CBT. He believes that most 3 level technical training courses could be taught using CBT because courses such as these tend to teach declarative knowledge, not higher level knowledge. CBT could potentially replace the majority of 3 skill level technical training courses, except for those courses which rely on interpersonal interaction, and practice on specialized equipment or simulated situations to develop important job skills (55).

Further, Lt Col Peterson states that the demand for CBT is increasing, and will continue to increase as the supply CBT modules are released to the field. As the demand for CBT increases, he predicts that the CBT development office, at the 3440th TTC, will not be able to develop new modules and simultaneously maintain and update the modules which will be in the field. He believes that the supply community is at an impasse right now because there is a need for what CBT can provide, yet the infrastructure for handling the large scale demand for CBT does not exist. He says, "The Air Force should decentralize the development of CBT by having CBT development teams at each ATC base" (55). He states that each team should consist of a commanding officer or NCO, a knowledge engineer, one subject matter expert per major career field, a number of CBT developers, and an administrative assistant (55).

The Need for Policy and Guidance. Although the development and use of CBT in the Air Force is only in its infancy, there has been an expressed need for policy in this area. However, it does not appear as if anything firm is soon forthcoming (9; 41; 55). While many people have expressed their vision of what the future holds for the development of CBT in the Air Force, there is a more immediate problem; at least concerning the development of CBT within the supply community. As of July 1991, the CBT development office at the 3440th TTC will no longer exist, as their manning positions are all temporary (41).

Lt Col Peterson says that it is not very likely that the Air Staff or ATC will create and distribute a policy, before 1991, which determines how CBT development in the Air Force will be organized, funded, or manned. It is possible that an additional MOA could be drawn up between ATC and AFLMC to allow the development of CBT in the supply career field to continue after July 1991, and the temporary manning positions could be extended indefinitely. This may suffice as a band-aid solution for a much larger problem, but should not be considered an acceptable long-term solution (55).

Learning

Learning refers to "the acquisition of knowledge which causes a relatively permanent change in specific behaviors...and is more than just remembering" (56:2). It is the ability to perform some task with skill.

In the Air Force, the traditional technical training (learning) methods are based on "the behavioralist traditions of B.F. Skinner...(who stated) that human behaviors are controlled by the immediate consequences following a behavior" (56:2). As a result, positively reinforced behaviors tend to be repeated. Applying Skinner's operant conditioning principles to programmed instruction have reduced the amount of time required to teach a technical skill (56:2).

Learning can be described in many ways. In the context of this research, we will consider 2 established scientific viewpoints; structural and functional. Also, we will look at a third viewpoint called mastery learning. A structural viewpoint, which is often associated with cognitive psychology, emphasizes "what" and "when" learning occurs. The functional perspective, on the other hand, describes under what "conditions" learning occurs (17:32).

Structural Perspective. The structural perspective defines learning in terms of human information processing. Information from the environment is input into the sensory register of the brain. Mental activities in the brain include pattern recognition, short-term memory, and long-term memory. Input is encoded in the brain in short-term and long-term memory (18:32). Most information processing models begin with the need for the learner to attend to the instructional material. Once the learner is attending, the

information is coded and stored temporarily in the working memory. Much of the information stored in the working memory is lost, but some of it is incorporated into long-term memory. Actual learning occurs when this final link is made into long-term memory (13:79).

Cognitive scientists realize the role of the trainee as a passive receiver of information has changed (18:91).

> Teaching and learning involve a transaction. As such, the process is an active one, not only for instructors, but also for trainees. Unfortunately, learners are often cast in the passive role...One of the key functions...is to identify an appropriate set of learning activities and experiences. In this way, trainees can become active partners in the teaching-learning process. (18:91)

New cognitive learning theories promote the concept of cognitive model development. This model consists of declarative knowledge, procedural knowledge, and systems knowledge. Declarative knowledge refers to specific tasks or principles about the task. Procedural knowledge refers to how the task is performed. Systems knowledge refers to how the task fits into other tasks (56:4). There is a tendency for cognitive models to increase the complexity of training technical tasks.

> To institute this form of training in a classroom environment would mean substantially extending the length of most resident courses. The desire of most organizations to reduce classroom time and move training closer to the actual work environment, makes the use of cognitive learning theories very unlikely. (56:3)

However, it may be possible to improve learning and reduce training time by combining the new cognitive learning theories with CBT (56:4).

Functional Perspective. The thesis of this concept states that the relationship between the environment and what a person does, has profound implications on learning. The present environment is not the only thing that helps or hinders learning. Changing events which occur before or after training will also effect the students' behavior (17:40).

Functional psychologists state that learning is not determined by age or personality, but by "species characteristics, biological maturation, or the history of interaction with a particular environment from the moment of conception" (17:33). In terms of CBT, the functional perspective indicates that students will learn depending on how well they have learned in the past (17:43).

Mastery Learning. Mastery learning is achieved when a person becomes so familiar with a subject matter, that he can perform with accuracy and speed. For example, when someone achieves mastery in a cognitive skill such as learning a foreign language, he is able to speak the new language fluently. "In situations where mastery of the subject matter is necessary, it is often the technique of choice" (16).

Mastery learning is appropriate for situations where a person needs to know information to be able to do a job safely, efficiently, or effectively. It is most applicable when the content of the knowledge can be expressed in verbal form, and when it is conceptual and factual in nature (as opposed to physical). Also, it is appropriate for learning information "on licensing tests, product knowledge, operating procedures, concept information, computer skills, and academic skills" (16).

Cowardin says that a behavioral learning system best complements the mastery learning concept. The behavioral approach defines learning as a change in behavior "which emerges during the lifetime of an individual", and is measured best by frequency of response. Behavioral learning involves repeated measurement of behavior over time. This approach does not "just present the material and leave the learning up to the student". Instead, this concept is interested in engineering behavioral change toward a reasonable goal. The 7 key features of a behavioral learning system are (16):

1. Define the goal in measurable terms.
2. Rely on the rate of response as a salient measure.
3. Control the consequences of relevant behaviors.
4. Evaluate methods as well as the students' performance, especially if the performance goals are not met.

5. Assume the student can learn from a properly controlled environment.

6. Measure often.

7. Employ a measurement that has scientific rigor.

Important Principles of Learning. There are many tactics and strategies which can be used to promote learning. Davies provides the following general principles, which may act as guidelines to facilitate learning (18:249):

1. Learners must be active rather than passive.

2. Frequency and recency are important. The more something is done, the more recent the performance, the better the learning.

3. Learning is purposeful; it is not reflexive. There is a conscious purpose, and this motivation needs to be recognized.

4. Reinforcement and feedback are essential. If people are not rewarded they will not learn. If they don't get feedback, their learning will not improve. They will fall into bad habits.

5. Learning should be pleasant and enjoyable. Unpleasant situations are avoided.

Measuring Learning. Often, learning is measured using a test or examination, which can be written or oral, knowledge or skills based. However, these learning measures are indirect and may not reflect actual learning. On the

other hand, good test scores may exaggerate learning, as when a trainee guesses a correct answer (18:229).

It is possible that traditional testing is not the best way to measure what has been learned. In the Air Force, this is evident by the inability of many technical school graduates (who pass the end-of-the-course test) who reach their first operational assignment, only to find that they cannot successfully perform the simple tasks for which they were trained (55). Despite its problems, measuring learning does have a place in assessment. As long as care is taken in the design of tests and examinations, valuable information can be obtained (18:229).

Tests can fall into two categories, descriptive or prescriptive. Descriptive tests which are analogous to traditional written examinations, measure the students ability to remember information. On the other hand, prescriptive tests measure the students ability to integrate the learned knowledge, in order to accomplish a task requiring a series of steps. Performance testing is nothing more than measuring how well the student performs in an actual or simulated work environment (55). Many experts agree that for many technical training applications, learning is best measured by prescriptive testing (18:229; 56).

Training

In a broad sense, the concept of training means "doing something to others so that they will do something differently" (43:48). The goal of technical, or skills training programs should be to give the learner the ability to reproduce a skill with accuracy, and to combine more than one skill to complete a job (66:39). Many organizations recognize that training is an important variable which affects productivity (12:64; 53:47). However, training programs within organizations are often "ad hoc and reactive functions" (53:49).

The term, "positive transfer of training", is often used to measure the degree to which trainees can effectively apply the knowledge, skills, and attitudes gained in a training context to the job (8:63). Baldwin and Ford proposed a model which compares the relationship between training inputs, training outputs, and conditions of transfer (8:63). Baldwin and Ford state that training inputs include the trainees' personal characteristics, the training design, and the work environment, while the training outputs include learning and retention. Conditions of transfer consider such concepts as maintenance and the ability to generalize. Baldwin and Ford concluded that for positive transfer to occur, the learned behavior must be generalized to the job context and maintained over a period of time while on the job (8:64).

Four principles of training have been identified which help to improve the positive transfer of training. They are as follows (12:65):

1. Make training content relevant to the trainees.

2. Make training objectives congruent with the work tasks you are trying to affect.

3. Make the training design systematic and be sure it relates directly to the training objectives.

4. Plan training delivery to respond to the trainees frame of reference.

When a training program proves to be ineffective, few will consider the idea that the wrong training tool was chosen. Instead, "the belief that training is not really important or effective tends to be reinforced" (40:26).

> Too often, when an organization is looking into using new technologies, the trainers will get hung up on the methodology and forget these concepts behind the process. The key is the job to be done should dictate the tools used, not the other way around. (40:26)

To ensure that training is properly planned, organized, and delivered, an 8 step model for developing a training strategy was proposed. This model highlights some of the important areas which must be considered throughout the training development process. These 8 steps are (40:25):

1. Find out what the problem is, and what learning is needed to solve it.

2. Analyze your training audience.

3. Develop specific, measurable learning objectives.

4. Decide which skills and attitudes will help the trainees reach their goal.

5. Examine the organizational resources and constraints.

6. Design the training program.

7. Produce and implement the program.

8. Evaluate the program to determine its effectiveness.

Diversity of Training. The diversity of training tools and the techniques which are available seems almost limitless. Given the apparent overabundance of possibilities, how does an organization answer the question, what is the best training media to use? "The 'perfectly professional' answer should be a resounding 'it depends'" (39:96). The material, audience, location, and objectives are important factors which organizations should consider when choosing a methodology (45:57). Figure 2 provides a list of some training techniques and tools which are commonly used today.

The Learning Continuum. Ganger and Christensen define the Learning Continuum as "a continuous set of learning activities which allows the user to acquire knowledge about his or her job" (25). They believe that the proliferation of microcomputers in the workplace has empowered employees, allowing them to generate and receive more information and data than ever before. "Empowerment has made the average

job increasingly complex and demanding, and more dependent on cognitive and decision making-skills" (25).

Techniques	Tools
Artificial Intelligence	Audiocassettes
Business Gaming	Flipcharts
Case Studies	Movies
CBT	Ovrhd. Projectors
Concurrent Training	Sound Filmstrips
Demonstration	Slides
Electronic Workbooks	Textbooks
Interactive Videodisk	Videocassettes
Lecture	
One-to-One Instruction	
Problem Solving	
Role-Playing	
Satellite Delivered Learning	
Self Instruction	
Seminar Style Training	
Simulations	
Teleconferencing	
Videoconferencing	

Figure 2. Training Techniques and Tools (5:91; 14:31; 35:32; 40:26; 45:57; 65:30; 71:84)

The Learning Continuum is a training approach which will help ensure success for employees in the 1990s. This concept states that training is an "on-going process and, like other resources, should reside at the individual workers workstation or personal computer (PC)" (25). The worker should have the power of deciding when and in what form the training will take place. As a result, training will integrate the new skills into the context of the workers job.

They propose that the Learning Continuum is very well suited for a CBT environment. Figure 3 identifies some adult learning needs which the Learning Continuum can address through a CBT medium.

Adult Learning Needs	The Learning Continuum
1. Adults need to know why	1. Pre-training activities introduce change, and remove fear of the unknown
2. Adults need to have control	2. Training occurs on demand and is available as required
3. Adults need to have the learning experience linked to the job	3. Activities are directly related to the job
4. Adults need to learn at their own pace, and to have sufficient time to master tasks and skills	4. Learning is on-going and learners work at their own pace

Figure 3. Comparison of Adult Learning Needs to Capabilities of the Learning Continuum (25)

The Learning Continuum consists of three levels; Preparation for the acquisition of knowledge, Acquisition of knowledge and skills, and Retention of knowledge and sharpening of skills. Figure 4 provides a description of these 3 phases in more detail.

A. Preparation for the Acquisition of Knowledge

1. Pre-class work: Provides the necessary information to establish the baseline level of knowledge and understanding required.

B. Acquisition of Knowledge and Skills

1. Tutorials: Prevent the training gap, solves the travel problem, and accommodates adult learning styles.
2. Practice opportunities and simulations: Prevents errors and supports classroom instruction by providing an opportunity to try new skills before using them in a real situation.

C. Retention of Knowledge and Sharpening of Skills

1. Practice and simulation: Skills need to be practiced and learning needs to be reinforced. Especially true when skills are used often.
2. Testing: The use of testing programs allows users to check their own skill levels and spot weak areas.
3. Performance support tools: These provide "just-in-time training", providing the information when it is needed.

Figure 4. Three Phases of the Learning Continuum (25)

QUEST Authoring System

The QUEST Authoring System was designed to be used by trainers, teachers, and anyone else who trains and educates people. QUEST makes it possible for the non-programmer to translate his thoughts and training ideas into computer-based training lessons and tests (4:v).

> QUEST is an authoring system, not an authoring language. The difference being that an authoring language requires programming skills to use it. With QUEST you can perform many of the same functions using menu screens and prompt lines which display the available functions in plain English. (4:v)

Therefore, people with no programming experience can create very sophisticated CBT programs utilizing, graphics, feedback, complex branching, internal answer evaluation techniques, and much more. QUEST is a very flexible program. It allows the user to transfer his own unique teaching style into CBT programs (4:v).

<u>QUEST Structure</u>. The QUEST Authoring System consists of several programs. These programs are interrelated and are centered around the main AUTHOR program. The different programs make it possible for the user to create, manage, and present CBT lessons (4:vi). Figure 5 illustrates the relationship between the QUEST programs.

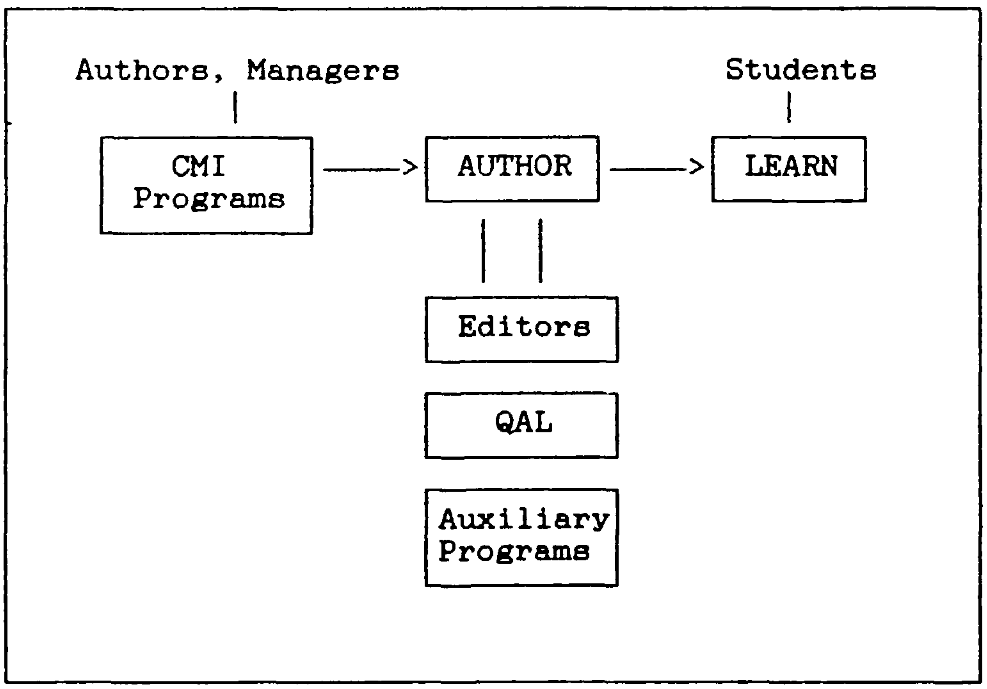


Figure 5. QUEST Configuration (4:vi)

The Computer Managed Instruction (CMI) programs are programs used as administrative devices. There are 3 CMI programs: REGISTER, CATALOG, and REPORT. The REGISTER program controls access to QUEST, only permitting registered users to enter programs. The CATALOG program establishes a catalog of the available lessons students can take. The REPORT program provides the manager or trainer with student lesson reports which can be used for student evaluation (4:vii).

The AUTHOR program is the main program used to actually create the CBT lessons. All the other programs within QUEST, with the exception of CMI programs, are additional tools used to enhance the lesson created in AUTHOR (4:vi).

> AUTHOR is the primary tool for creating your CBT courses. It allows you to enter text, draw graphics and illustrations, create animation, set up branching, ask questions and specify how the student's answer will be analyzed, provide feedback, and many other options. (4:vi)

The LEARN program allows the students to view the lesson, answer questions, take tests, and receive feedback on performance during the lesson (4:vii).

The QUEST Editor programs expand the power of the text and graphics capabilities found in the AUTHOR program. There are three separate editors available: Shape Editor, Character Editor, and the Text Editor. The Shape Editor allows the user to create graphics and store them for later use when developing lessons. The Character Editor allows the user to create unique character sets, such as

mathematical symbols and foreign language characters. The final editor available is the Text Editor. The Text Editor is used to write messages and batch files. While in the LEARN program, students can use the Text Editor to write messages to their instructor (4:vii).

The QUEST Authoring Language (QAL) provides the user with the power to develop extremely sophisticated CBT lessons which are beyond the abilities of the QUEST Authoring System used alone. The structure and logic of QAL is very similar to Pascal (4:viii).

> A QAL program could be used to transfer information between a database program and a QUEST lesson, or to monitor various gauges and instruments in a flight simulation. (4:viii)

There are several Auxiliary programs available to the user. The Auxiliary programs allow the user to import images from outside programs, check for flaws in lesson structure, and many more available functions (4:viii).

The Storage and Distribution Entry-Level CBT Program

This CBT program, which is used in this study, was designed by the Lowry AFB CBT team and developed by the AFLMC programmer using the QUEST Authoring System. The program consists of three parts; tutorial, drill and practice, and a CBT Mastery test.

Tutorial. The tutorial begins with an introductory portion which explains to the test subjects that after the lesson is complete they will be able to properly store

property in the correct warehouse location. Also, the introductory portion tells the students that they will need to use two chapters from AFM 67-1 for reference during the lesson. The lesson portion of the program uses the techniques of feedback and remediation when necessary. The tutorial is organized into three knowledge clusters. Each cluster teaches the students one important procedure or technique involved with the correct storage of property in a warehouse location. The first cluster instructs students on the difference between due-out-releases and management notices, and the two different types (I046 and I102) of management notices used to store property. The second cluster introduces the students to the breakdown of a warehouse location. Finally, the third cluster instructs the students on the five step process for correctly storing property in a warehouse location.

The tutorial utilizes a combination of lesson (instructional) screens, memory check (questions) screens, and summary screens to teach the students to correctly warehouse property. Lesson screens are used to present the material to the students. The lesson screens were designed with a combination of graphics and text for the presentation of the instructional material.

After a few lesson screens are presented to the students, memory check questions are used to determine if they comprehended the previously presented material. Memory

check questions can be true/false, multiple choice, fill-in-the-blank, or matching questions. If the student correctly answers the memory check question, positive feedback will be displayed on the memory check screen. However, if the student answers incorrectly, he will be given feedback and may be diverted to remediation. Remediation consists of several lesson screens structured slightly differently than the previous lesson screens on the material. After the remediation lesson screens are presented, memory check questions again check for student comprehension. If the student still has problems answering the questions correctly the program stops the lesson and directs the student to contact his supervisor or trainer for assistance. The last screen in each knowledge cluster provides a summary of what the student should have learned. Figure 6 shows a flow chart of the presentation logic in the tutorial portion of the program. Knowledge cluster 3 follows the same general pattern as clusters 1 and 2. The numbers in each box represent the number of each type of screen presented.

Drill and Practice. The drill and practice portion of the program enables the student to fine tune the skills and knowledge attained from the tutorial. Prior to beginning the practice questions the students are given the opportunity to continue with the drill and practice portion of the program, review the tutorial portion, or quit the

program and reenter at a later time at the drill and practice location.

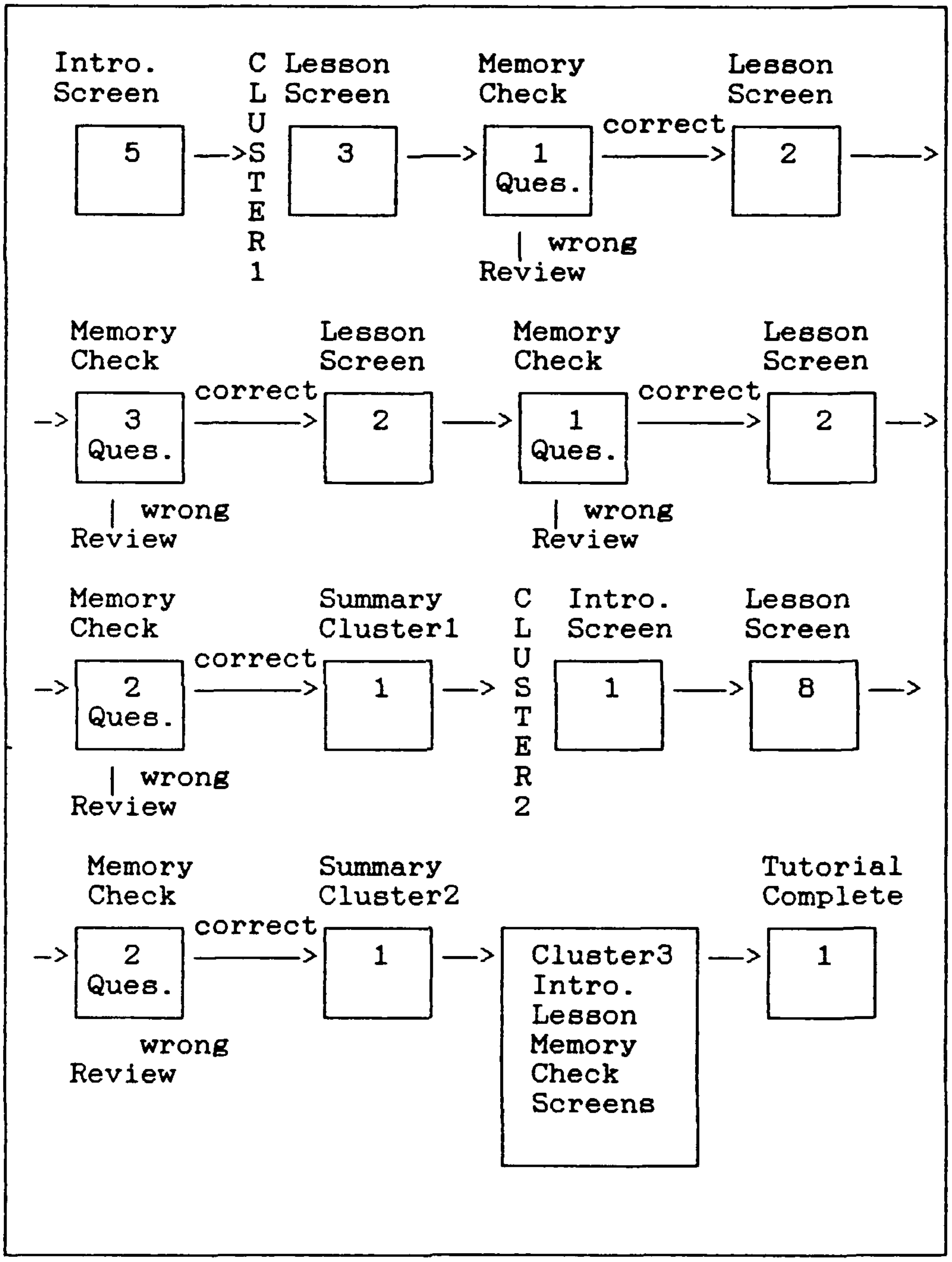


Figure 6. Flow Chart of Tutorial in the CBT Storage and Distribution Entry Level Program

The drill and practice consists of eight questions very similar to the memory check questions in the tutorial. If the student answers the questions correctly, positive feedback is displayed. If the student answers the question incorrectly, he will either receive feedback explaining why the answer was incorrect, or he will receive feedback along with remediation on the material in question. The flow chart of the drill and practice portion of the program is shown in Figure 7.

Mastery Test. The Mastery Test was developed to test the student's knowledge in three knowledge clusters. The Mastery Test contains 13 primary and 5 adaptive questions. The adaptive questions are added when certain questions are answered incorrectly. The adaptive questions give the test subject the opportunity to answer questions which are similar to the one(s) that were originally missed. The test subjects are not penalized if they answer these additional questions correctly. No feedback is given to the test subjects because the Mastery Test is used only for the purpose of evaluation. A flow chart of the sequence of the Mastery Test questions is depicted in Figure 8. The first knowledge cluster contains two Yes/No primary questions on identifying if property has been delivered to the correct warehouse. The second knowledge cluster uses 4 fill-in-the-blank questions dealing with the identification of the correct stockroom, bin row, horizontal bin level, and

```
Question #1           Negative
correct? ——>no——> Feedback ——> Question #2
    |
   yes
    |
Question #2           Remediation/
correct? ——>no——> Review ——> Question #3
    |
   yes
    |
Question #3           Remediation/
correct? ——>no——> Review ——> Question #4
    |
   yes
    |
Question #4           Remediation/
correct? ——>no——> Review ——> Question #5
    |
   yes
    |
Question #5           Negative
correct? ——>no——> Feedback ——> Question #6
    |
   yes
    |
Question #6           Remediation/
correct? ——>no——> Review ——> Question #7
    |
   yes
    |
Question #7           Negative
correct? ——>no——> Feedback ——> Question #8
    |
   yes
    |
Question #8           Negative
correct? ——>no——> Feedback
    |
   yes
    |
Mastery Test
```

Figure 7. Flow Chart of Drill and Practice

vertical bin level locations. The third and final cluster contains 6 multiple choice questions and a fill-in-the-blank question pertaining to the 5 step procedure for storing property in the correct warehouse location.

```
Questions #1 & #2
   |
#1 & #2              Adaptive
correct? --->no---> Question   ----> Question
   |                    A              #3
   | yes
Questions #3,#4,#5,#6
   |
#3 thru #6 all       Adaptive
correct? --->no---> Questions  ----> Question
   |                 B,C,D,&E          #7
   | yes
Questions #7,#8,#9,#10,#11,#12
   |
#7 thru #12 all
correct? --->no---> End
   |
  End
```

Figure 8. Flow Chart of Mastery Test Questions

Summary

This chapter reviewed the current literature relating to CBT. Included was a review of the history of CBT, methodology and design of CBT, advantages and disadvantages of using CBT, and a discussion of some prior experiments which examined the effectiveness of CBT. Also, the current and future status of CBT development in the Air Force was discussed, as were current learning theory and training

concepts. Further, the QUEST authoring system was reviewed, and a discussion of the Storage and Distribution Entry-Level CBT program was included.

This review of the literature provided a broad, yet thorough, understanding of many important topics which are directly related to this research. Chapter III expands on this understanding, by including a review of the literature as it pertains to the methodology. Further, Chapter III describes the methodology which was used to objectively examine the research hypothesis.

III. Methodology

Introduction

This chapter explains how the research problem was investigated using an experimental research design. The research problem directly lends itself to experimentation because, "experiments are studies whose implementation involves intervention by the researcher beyond that required for measurement" (23:130). Intervention is required in order to determine the relative significance of the experimental treatments. Without the researchers' intervention, it would be difficult to adequately compare the experimental treatments, and to identify any significant differences existing between the treatments. The experimental methodology will make it possible to identify significant changes in the dependent variable, which result from manipulation of the independent variable.

This chapter reviews the pertinent methodological literature, and restates the primary research hypothesis. Also, the independent and dependent variables are discussed, as are the experimental design and the research procedures used to conduct this experiment. In addition, the sampling method is discussed, and the methods of data analysis are explained to provide a framework for how the data will be analyzed in Chapter IV.

Literature Review of the Methodology

This literature review is discussed in two parts. First, the research methods and design used in this study are discussed. This discussion includes the post-test-only control group design, and the stratified random sampling technique.

In the second portion of this review, specific statistical techniques are discussed. This discussion includes both parametric and non-parametric techniques for analyzing the data. The discussion of parametric techniques will include the Central Limit Theorem (CLT), the one-way analysis of variance (ANOVA), the Bonferroni multiple comparison procedure, and the pooled variance t-test. The discussion of non-parametric techniques includes the Kruskal-Wallis One-way ANOVA by Rank (K-W ANOVA) and the Mann-Whitney U test.

Research Design. The post-test-only control group design does not rely on the pre-testing of the test subjects. Emory believes that pre-tests are not necessary when samples are selected at random (23:122). He justifies this belief by saying, "internal validity threats from history, maturation, selection, and statistical regression are adequately controlled by random assignment" (23:122). The experimental results of the post-test-only control group design are measured by taking the difference between the post-test results of the various experimental groups (19).

This methodology measures experimental effect by comparing the differences in post-test scores between the various treatment groups. The post-test-only control group design is effective when samples are randomly selected. Also, this design eliminates the "threat of testing", which is the possibility that pre-testing may give the test subjects an idea of the expected or hypothesized outcome of the experiment (19). Although this design is very powerful, it is subject to certain limitations. "Differential mortality between experimental and control groups continues to be a potential problem" (23:122).

The stratified random sampling technique partitions, or stratifies, the population into a number of mutually exclusive subgroups, or strata (23:306; 47:308). This sampling method, "is almost always more efficient statistically than simple random sampling and at its worst is equal to it" (23:307). Stratified random sampling is more powerful because it ensures that sub-groups are represented in the same proportion in each of the three treatments as they are found in the true population (19).

> Stratified sampling usually provides more accurate estimates of the population mean than does a simple random sample of the same size because the variability within the strata is usually less than the variability over the entire population. (48:1148)

There is no standard procedure to determine how many strata to use. Emory states that, "theoretically the more strata, the closer you are likely to come to maximizing

inter-strata differences and minimizing intra-stratum variances" (23:308). Advantages of stratified random sampling are as follows (23:307):

1. Increases the samples statistical efficiency.

2. Provides adequate data for analyzing the sub-populations.

3. Enables different research methods and procedures to be used in different strata.

Statistical Methods. This section describes the difference between parametric and non-parametric statistics, and the specific parametric and non-parametric techniques which may be used to analyze the experimental data. The actual sample size, distribution, variability, and sampling method will determine whether parametric or non-parametric techniques are used. When using parametric statistics, the data must meet certain criteria or assumptions. If the data does not meet these criteria, then non-parametric statistics will be used.

Parametric Statistics. Siegel defines a parametric statistical test as a test "whose model specifies certain conditions about the parameters of the population from which the research sample was drawn" (60:30-31). There is no common agreement as to what constitutes a sufficiently large sample size. Unless the population is approximately normal, small samples generally do not result in a sampling distribution that is normally distributed (47:315). The

Central Limit Theorem (CLT), "provides the theoretical framework for most statistical estimation and tests of hypothesis" (47:316). The CLT implies that regardless of the shape of the frequency distribution of the population, the frequency distribution of the sample mean, in repeated samples of a certain size, tends to approach a normal distribution as the sample size increases (10:73; 62:47). Many researchers consider that a sample size of 30 or more qualifies as a large sample (19; 33:273; 35; 47:315; 48:321). The CLT is easy to apply because few assumptions must be met in order to use it.

> Apart from the condition of random sampling, the theorem requires very few assumptions; it is sufficient to say that sigma is finite and that the sample is a random sample from the population. (62:48)

The one-way ANOVA is used when the experiment uses a single independent variable to estimate the dependent variable (35; 49:91). This test is used to determine if there is a statistical difference between the means of two or more samples (47:395). The one-way ANOVA uses the F-test statistic, which is a measure of the between sample variability divided by the within sample variability (35; 49:91). The one-way ANOVA is based on the following three assumptions (10:245):

1. Samples come from normal populations.
2. Random and independent sampling is used.
3. Population variance is constant among groups.

Figure 9 describes the one-way ANOVA hypothesis test, and provides the criteria for rejection of the null hypothesis (35).

Although the one-way ANOVA can determine if at least one of the sample means is significantly different, it cannot determine which specific sample means are different. There are several multiple comparison techniques to choose from which will determine exactly where these differences lie (35). This review will only consider one of these multiple comparison techniques, the Bonferroni procedure. This procedure results in confidence intervals that are at least 100(1-alpha)% confident, and is a function of the mean square error of the data (22:358; 48:864). When the interval contains the number zero, meaning that the samples may have the same mean, the comparison is not considered significantly different. However, if zero is not within the interval, then the comparison is significantly different (35).

Miller states, "no method is uniformly best for all sets of data", because each multiple comparison technique is based on a different set of assumptions (49:236). The Bonferroni multiple comparison procedure controls the experiment-wise error rate by pre-selecting the samples to be compared. Also, this technique does not permit data snooping, which is basing the comparisons on data which is not pre-selected (35).

H_o: $\mu_1 = \mu_2 = \mu_3$ no significant difference exits)

H_a: at least one μ_i does not equal 0
(a significant difference does exit)

Test Statistic:

$$F = \frac{SST/(p-1)}{SSE/(n-p)}$$ where,

$$SST = N_{x1}(X_{x1}-X)^2 + N_{x2}(X_{x2}-X)^2 + \ldots N_{xn}(X_{xn}-X)^2$$

$$SSE = \Sigma[(X_{x1}-X_{x1})^2] + \Sigma[(X_{x2}-X_{x2})^2] + \ldots \Sigma[(X_{xn}-X_{xn})^2]$$

p=number of populations

n=number of observations in the sample

Rejection Region:

$$F > F_\alpha$$

Conclusion: Reject H_o if:

1) test statistic lies in rejection region
OR
2) p-value$<\alpha$

Figure 9. Hypothesis Test for the One-way ANOVA (28)

This procedure can be used even if the ANOVA does not identify any significant differences between the samples. This is illustrated by the fact that at a .05 level of significance, there is still a 5% chance that the null hypothesis will be rejected when it is true. Therefore, there is a 5% chance that a significant difference exists, but was not identified (35).

The pooled variance t-test is used to determine if a significant difference exists between two samples. This test uses the t-test statistic, which measures the difference in the sample means minus the hypothesized difference, divided by the quantity, pooled variance times a function of the two sample sizes. To apply this test, three assumptions must be met (35):

1. Samples come from normal populations.
2. Random and independent sampling was used.
3. The variance between the samples is equal.

Figure 10 describes the pooled variance t-test hypothesis test.

Non-parametric Statistics. A non-parametric statistical test is a test "whose model does not specify conditions about the parameters of the population from which the sample was drawn" (60:31). Non-parametric statistical techniques do not rely on as many assumptions as do parametric techniques. As a result, your conclusions do not require as many qualifications either. A suitable conclusion drawn after using a non-parametric technique may say, "Regardless of the shape of the population(s), we may conclude that..." (60:3). Non-parametric techniques are often referred to as "ranking tests" or "order tests" because they focus on the rank or order of the scores, not on the numerical values (48:946-947;60:3).

H_o: $\mu_1 - \mu_2 = 0$ (no significant difference exists)

H_a: $\mu_1 - \mu_2 =/ 0$ (a significant difference exists)

Test Statistic:

$$t = [(x_1 - x_2) - D_o]/[p(1/n_1 + 1/n_2)]^{1/2}$$

where: x=avg. score for sample 1 or 2

D_o=hypothesized difference (0 for small samples)

n=sample size of sample 1 or 2

$p = [(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2]/[n_1 - n_2 - 2]$

s=standard deviation of sample 1 or 2

Rejection Region:

$$t > t^{\alpha/s} \quad \text{or} \quad t < t^{\alpha/2}$$

Conclusion: Reject H_o if:

1) test statistic lies in rejection region

OR

2) p-value<α

Figure 10. Hypothesis Test for the Pooled Variance t-Test (35)

Siegel states four primary advantages to using non-parametric techniques. They are:

1. The shape of the distribution is not important.

2. The scores do not have to be numerically exact, as long as they are ranked.

3. Non-parametric techniques are generally computationally simpler than their parametric counterparts.

4. Non-parametric techniques are very useful when you have a small sample size (60:vii).

The K-W ANOVA is the non-parametric technique which is analogous to the parametric One-Way ANOVA. This test is used when you have independent random samples (60:161). This test will tell you if the independent samples are from different populations.

If the experimental design has three or more treatments, this test can only determine if a significant difference exists, but can not locate the significant difference (60:184-186). Figure 11 shows the hypothesis test for the K-W ANOVA.

H_o: k samples come from the same population (no significant difference exists)

H_a: at least one of the k samples comes from a different population (a significant difference exists)

Test Statistic:

$$H=\frac{12}{N(N+1)}\sum \frac{R_j^2}{n_j}-3(N+1)$$

where,

k=number of samples
n_j=number of cases in the jth sample
$N=\Sigma n_j$, the number of cases in all samples combined
R_j=sum of ranks in the jth sample

Rejection Region: $H>H_a$

Conclusion: Reject H_o if:

1) test statistic lies in rejection region
OR
2) p-value<α

Figure 11. Hypothesis Test for the Kruskal-Wallis One-way ANOVA by Rank (60:185-186)

When using parametric techniques, the One-way ANOVA is used to determine if a significant difference exists between any of the treatments, and a multiple comparison technique is used to identify which specific treatments are significantly different from one another. Since there is not a non-parametric equivalent to the multiple comparison technique, a non-parametric two-sample test should be used to determine which treatments are significantly different. However, Siegel makes a very important point:

> Only when an over-all test (such as the K-W ANOVA) allows us to reject the null hypothesis...are we justified in employing a procedure for testing for significant differences between any two of the k samples. (60:160)

If a non-parametric two-sample test is used without first conducting an over-all test, the probability of a Type I error is increased, as is the probability of rejecting the null hypothesis when it is actually true. Siegel says:

> It can be shown that, for five samples, the probability that a two-sample statistical test will find one or more 'significant' differences, when alpha=.05, is p=.40. That is, the actual significance level in such a procedure becomes alpha=.40. (60:159-160)

The Mann-Whitney U test is a two-sample test which is used to determine whether two independent groups have been drawn from the same population. When the data is at least ordinal, this test is one of the most powerful non-parametric tests, and is a good alternative to the parametric t-test (60:116). Figure 12 illustrates the hypothesis test for the Mann-Whitney U test.

H_o: samples come from the same population (no significant difference exists)

H_a: samples come from different populations (a significant difference exists)

Test Statistic:

$$U=n_1n_2+\frac{n_1(n_1+1)}{2}-R$$

$$U^1=n_1n_2-U \qquad \text{where,}$$

n_1=number of cases in the smaller sample
n_2=number of cases in the larger sample
R=sum of the ranks assigned to the group whose sample size is n_1

Rejection Region:

Reject H_o if the smallest value, either U or U^1 <the critical value of U from the Mann-Whitney table

Figure 12. Hypothesis Test for the Mann-Whitney U Test (60:118-120)

Research Hypothesis

The Xerox corporations' United States marketing group CAI manager said, "if it is used appropriately, CBT can be more effective than many more traditional training methods" (40:22). This belief parallels the fundamental research hypothesis for this study, which states that CBT is a more useful learning tool than the three skill level CDC for direct duty assignment (DDA) Material Storage and Distribution Specialists, AFSC 645X1. In other words, the

direct duty 645X1s who use CBT, will more effectively gain the knowledge, understanding, and skills necessary to achieve their three skill level, as compared to the direct duty 645X1s who receive the traditional 645X1 CDC training.

Independent Variable

The type of training which is administered to the test subjects comprises the independent variable. The test subjects received one of three possible treatments. The first treatment is the CBT module, the second treatment is a text training module, and the third treatment represents the control group. The subjects in the control group did not receive any training, but were administered the post-test and the task analysis.

The CBT module was developed using the QUEST authoring system, version 3.0. The text training module is composed of excerpts from the 64531 CDC Apprentice Materiel Facilities Specialist (1989), which correspond to the objectives used in the CBT module.

Dependent Variable

The dependent variable, which is a function of the type of training administered to the test subjects, represents the degree of learning which the test subjects will demonstrate as a result of receiving training. Learning will be measured in two ways:

1) using the test subjects' post-test scores, and

2) observing their performance in a task analysis (this is explained in more detail under the subheading, Post Test).

Experimental Design

The post-test-only control group design will be used to conduct this experiment. Typically, the post-test-only control group design relies on the use of simple random sampling. However, the stratified random sampling technique was used for this research project. By minimizing between-group variability, this method reduces the probability that other factors will effect the experimental results. In other words, stratifying the test subjects helps to minimize the effect other factors may have on the experimental results. Figure 13 describes the post-test-only control group design as it relates to this study.

Selection criteria	Experimental treatment	Post-test
R	x_1	P
R	x_2	P
R	nt	P

where,

R=random assignment of test subjects
x_1=CBT training module
x_2=CDC training module
nt=no treatment (control group)
P=post-test

Figure 13. Post-test Only Control Group Design (23:122).

In terms of this research, the test subjects will be assigned to one of the three experimental treatments based on their AQE test scores in the general category. The Air Force uses the AQE test score to determine the career field eligibility of individuals who are entering the Air Force. Using the general score is preferred because the Air Force uses it as a common criteria for entrance into the 645X0 and 645X1 career fields (21:Attachment 37).

New students in the Supply Inventory Management Specialist Course, AFSC 645X0, at the 3440th TTC, were used to make inferences about the population of Supply Material Storage and Distribution Specialists, AFSC 645X1. This situation is unavoidable because 645X1s do not receive formal technical training, instead they are assigned directly to their duty station upon completion of Basic Military Training School (BMTS) at Lackland AFB, Texas. Due to the BMTS graduation schedule, and the relatively small number of future 645X1s who graduate from BMTS at any given time, it is not feasible to use BMTS graduates as test subjects.

This research includes a statistical analysis which shows that the two populations, 645X1s and 645X0 experimental subjects, are not significantly different. Figure 14 summarizes the minimum AQE test score requirements for selection as a Supply Inventory Management Specialist, AFSC 645X0, and a Material Storage and Distribution Specialist, AFSC 645X1.

Research Procedures

This section describes the procedures used to conduct this experiment. The logistical limitations imposed by this study, as well as the details of how the stratified random sampling technique was implemented, are discussed in detail.

AFSC	Minimum score	Category
645X0	45	Admin. or
	43	General
645X1	30	General

Figure 14. Minimum AQE Test Scores for Entry in AFSC 645X0 and 645X1 (21)

In addition, the data collection procedures are explained, followed by a discussion of the post-test. This section ends with a discussion of the personal information questionnaire, and the methods used for data analysis.

Logistical Limitations. Although very straightforward in design, this research project poses an interesting logistical challenge, which has three root causes. The first cause is the geographic distance between the authors, assigned to Wright-Patterson AFB, OH, and the test subjects, assigned to the 3440th TTC. The second cause is a result of the test subjects' limited availability. They were only available for a maximum of two duty days before beginning their initial technical training. To minimize the possibility that advance knowledge of supply theory and procedures could introduce any bias, the experiment must be

conducted before the test subjects receive any technical training.

In addition to their limited availability, recent budget cuts have reduced the number of students available per week, from approximately 40 students to approximately 10-15 students. Therefore, the experiment was conducted on four separate occasions to ensure that an adequate sample size was taken.

Details of Sampling Method. Each time the experiment was conducted, the general scores from the AQE test for the test subjects were ranked. This ranked data was divided, or stratified, into four quartiles. The top 25% of the scores were assigned to the first quartile, the upper-middle 25% of the scores were assigned to the second quartile, the lower-middle 25% were assigned to the third quartile, and the lowest 25% of the scores were assigned to the fourth quartile. Once all test subjects were assigned to a specific quartile, the subjects within each quartile were randomly selected and assigned to one of the three treatments; CBT, CDC, or the control group. Figure 15 describes how the strata are segregated, and Figure 16 identifies the test subject composition in each treatment. The optimal sample size for this research effort is determined by applying the following formula (1:12):

$$n=[N(z^2)*p(1-p)]/[(N-1)*(d^2)+(z^2)*p(1-p)]$$ where;

n= sample size N= population size
p= maximum sample size factor d= confidence level
z= z-test statistic

Data Collection. This section explains how the data was collected. Given the limited amount of travel time available for the authors, and the limited availability and

Ranked AQE scores (%)	Quartile assigned
76 to 100	first
51 to 75	second
26 to 50	third
0 to 25	fourth

Note: Only AQE scores from the general category were used for sample stratification

Figure 15. Strata Determination for Sampling Technique

Treatment	Composition
CBT	1/4 from first quartile
	" " second quartile
	" " third quartile
	" " fourth quartile
CDC	1/4 from first quartile
	" " second quartile
	" " third quartile
	" " fourth quartile
Control	1/4 from first quartile
	" " second quartile
	" " third quartile
	" " fourth quartile

Note: Test subjects within each strata will be randomly assigned to the treatments

Figure 16. Composition of Experimental Treatments

number of tests subjects, a sound logistics plan was critical to the success of this research. All details were

coordinated ahead of time to ensure that the experiment flowed smoothly.

A POC was established at the 3440th TTC, and his active participation played a key role in the efficiency with which the experiment was conducted. The POC was responsible for the preparation of many details such as scheduling the test subjects in advance, notifying them of their appointments for the experiment, and ensuring availability of adequate classroom space and microcomputer support. Travel to Lowry AFB was planned to occur during the weeks when a maximum number of students were scheduled to begin class.

Upon arrival at Lowry AFB, the author immediately determined the composition of each treatment. A copy of the procedures used to determine treatment composition is found in Appendix B. After determining treatment composition, the CBT program was loaded into the microcomputers and adequate copies of the CDC text material and the post-test were made available. Once details such as these were completed, the experiment was set to begin.

The test subjects within each treatment were segregated from those in the other treatments for the duration of the experiment. This ensured that no inter or intra-treatment interactions occurred, potentially biasing the data. The experiment administrator read a prepared introduction to each treatment. This introduction provided the test subjects the information they needed to complete their

specific treatment. A copy of the prepared introductions is provided in Appendix C.

Once the prepared introductions were read to the test subjects, they began their respective training modules. The test subjects in the control group immediately received the post-test. When all of the test subjects in the CBT and CDC treatments completed their training modules, they were allowed a 15 minute break, which was monitored to ensure that no information was transferred between individuals. After the break, the CBT and CDC test subjects received the post-test.

Once the post-test was completed, the test subjects were taken to the base supply squadron where they were asked to perform a task analysis. Specifically, each test subject was given a piece of property and a management notice, and asked to properly stock the property. The students were evaluated for their knowledge of the proper procedures, and the sequence with which the procedures should be performed. Once all of the test subjects completed the task analysis, the data collection phase of the experiment was complete.

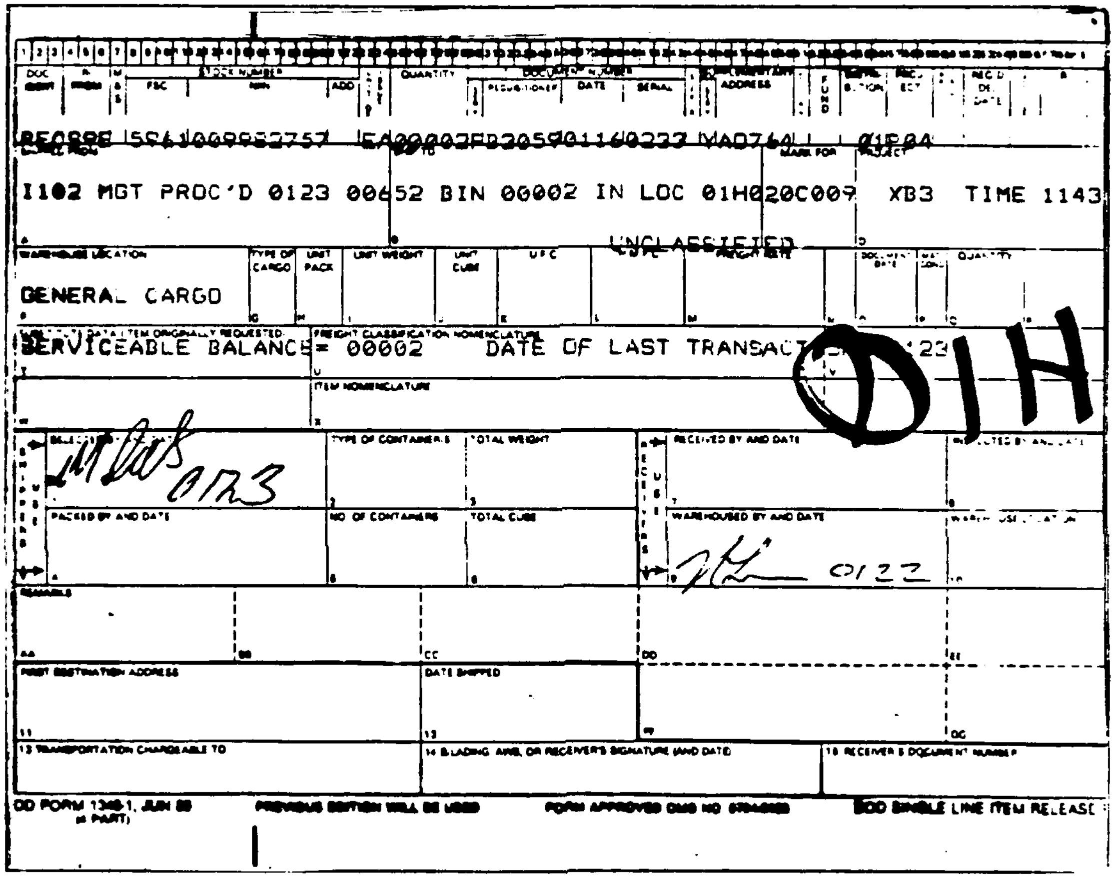
Post-test. The test subjects were evaluated in two ways. The descriptive post-test provided a quantitative measurement, which was used to measure the degree of learning which took place during the CBT and CDC treatments. Results from the control group provided a baseline from which to compare the scores. The mastery test contained in

the prototype CBT program was used as the experimental post-test. Since the text module and the CBT module cover the same material, the prototype CBT program mastery test was administered to all of the test subjects. Using the same post-test for all of the test subjects ensured that the degree of learning was measured consistently within each treatment.

The task analysis provided another quantitative measurement. It identified the degree to which the test subjects in each treatment could transfer their newly acquired knowledge to a "real-world" scenario. During the task analysis, the subjects were taken into the supply warehouse at the Lowry AFB Supply Squadron, and read a short introduction which was designed to help them understand the scenario. After receiving the introduction, they were given a management notice and a piece of property, and asked to properly store the property in the warehouse. Further, they were asked to verbalize the steps they performed so that the monitor could more easily understand and follow their logic. Figure 17 provides a copy of an actual management notice which was used during the task analysis. A copy of the task analysis introduction is found in Appendix D, and a copy of the experimental checklist used to evaluate the test subjects performance is found in Appendix E.

In addition to recording the scores from the post-test and from the task analysis, the length of time the test

subjects used to complete the training, testing, and task analysis portions of this experiment were measured. This data was used to determine the effect CBT has on the amount of time required to complete these functions.


I102 MGT PROC'D 0123 00652 BIN 00002 IN LOC 01H020C009 XB3 TIME 1143

UNCLASSIFIED

GENERAL CARGO

SERVICEABLE BALANCE= 00002 DATE OF LAST TRANSAC

DIH

0123

0122

DD FORM 1348-1, JUN 86

SINGLE LINE ITEM RELEASE

Figure 17. Management Notice Used During Task Analysis

Questionnaire. The questionnaire contains questions designed to gather demographic information from the test subjects. Areas such as educational level achieved, previous computer experience, age, etc. were considered. This data will be used to help identify correlations with the dependent variable, should the results prove

inconclusive, and to provide demographic information from the test subjects. A copy of the questionnaire is found in Appendix F.

Data Analysis. This section describes the parametric and non-parametric statistical tests used to analyze this data. The software program Statistix II: An Interactive Statistical Analysis Program for Microcomputers (Statistix), was used to conduct the statistical tests.

If parametric statistical techniques were used, the software program titled, Statistical Analysis Program (SAS) could be used to perform the data analysis. SAS's PROC ANOVA command would be used to conduct a one-way ANOVA. Also, the /BON option associated with the PROC ANOVA command would be used to perform Bonferroni's procedure for multiple comparisons (35; 59:224;236). Statistix would be used to conduct Bartlett's test for equality of variances between the samples used to conduct the pooled variance t-test. Bartlett's test would also be used to test equality of variances between the treatment data in the one-way ANOVA (52:5.56).

The pooled variance t-test would be used to compare the AQE test scores in the administrative category, between a sample of 645X0 experimental subjects, and a random sample of newly assigned 645X1s. The Bonferroni procedure would be used to identify which treatments were significantly different, regardless of the results of the one-way ANOVA.

If non-parametric techniques are used, Statistix will be used to compute the K-W ANOVA, the Mann-Whitney U Test, the pooled variance t-test, and any other tests deemed appropriate.

Review of Experimental Methodology

From the very beginning, the purpose of this research was to objectively examine the hypothesis that CBT is a more effective training tool than CDCs for training DDA supply warehousemen. The authors directed a great deal of effort towards developing a methodology which would allow a clear examination of the experimental hypothesis. They went to extreme lengths to ensure positive control of internal and external validity, and to eliminate the negative effects of potential biasing elements. As a result, the authors are very confident that the experimental methodology which they applied is sound, and that the results of this research are convincing.

There is not a single geographic location where an acceptable number of new Air Force DDA supply warehousemen are located at any one time. Therefore, the authors chose to use airmen who were preparing to enter the Supply Specialist technical training course, AFSC 645X0, at Lowry AFB, as the test subjects. The choice to use 645X0s for a study aimed at 645X1s immediately raises some understandable doubts about the generalizability of the experimental results. However, the authors have closely examined the

selection criteria which the Air Force uses to select airmen for entrance into the 645X1 and 645X0 career fields, and they provide a statistical analysis which supports the idea that the two populations are not significantly different from one another.

The authors applied the post-test-only control group design to this research, using three experimental treatments. The test subjects in the first treatment were trained using a CBT module which was designed by the Lowry AFB CBT team and developed by AFLMC. The test subjects in the second treatment were trained using material extracted from the 64531 CDC. The material which was extracted from this CDC was very carefully chosen to match the same training objectives that the CBT module uses. The test subjects in the third treatment, the control group, did not receive any training.

After the training sessions were conducted, all of the test subjects were administered an identical post-test which measured their knowledge level of the training objectives. Immediately following the post-test, the test subjects were taken to the base supply squadron where they were given a realistic scenario, and asked to perform the task for which they were trained. Specifically, they were given a management notice and a piece of property and asked to perform the necessary steps to properly store the property in the warehouse.

As a result of this methodology, it is possible to objectively measure the amount of cognitive knowledge the test subjects gained from their training, and to identify how transferable that training was to an actual work situation. Also, the training time for each treatment was easily measured, and these times were compared to the results of the post-test and the task analysis.

Summary

This chapter discussed how the research hypothesis was objectively evaluated. The introduction, which explained why an experimental design was chosen, was followed by a review of the methodological literature. This literature review summarized the current literature as it pertains to research methods, design, and the statistical techniques which may be used for this study.

The research hypothesis was restated, and the independent and dependent variables were identified and discussed. Also, specific details of the experimental design and the research procedures, were followed by a discussion of the sampling technique used. Finally, the specific statistical tests which were to be used were discussed.

IV. Data Analysis

Introduction

This chapter will address each of the seven investigative questions originally posed in Chapter I. Included in the investigative questions is an analysis of demographic information, which is offered to gain some insight into the test subjects' characteristics. Finally, the data is summarized to provide a brief, logical, and cohesive statement of the results of this research.

This chapter will provide a summary of all hypothesis tests performed. The actual computer output for each hypothesis test was produced using the Statistix software package, and is contained in Appendix G.

Investigative Question #1

What are the current base level training methods for DDA supply warehousemen, AFSC 645X1?

Telephone interviews were used to determine the present training methods currently used throughout the Air Force for training DDA 645X1s.

CMSgt Lewis, Directorate of Supply, Headquarters Strategic Air Command (SAC), said that most SAC units are relying on CDCs to train their DDA supply warehousemen. To supplement the CDCs, some SAC units have obtained portions of the training plan from the discontinued AFSC 645X1 Initial Training Course, which was formerly taught at Lowry AFB. CMSgt Lewis stated that SAC's failure rate for the

64531 CDC end-of-course examination has risen since the initial 645X1 course was terminated at the 3440th TTC (44).

Jack Hoskins, Training Section supervisor at Plattsburgh AFB, New York, stated:

> The DDA personnel at Plattsburgh Air Force Base use the 64531 CDC's for their initial training in storage and distribution procedures. This is the standard training for 645X1 personnel throughout SAC. (36)

Linda Neri, Chief of Resources, Headquarters Tactical Air Command (TAC), commented that it is TAC's policy to allow the base level training sections to develop and implement training programs for DDA 645X1 personnel. She believes that most initial training for DDA 645X1 personnel at base level consists of a combination of the 64531 CDCs and OJT (51).

Mrs. Mary Snook, Training Section supervisor at Myrtle Beach AFB, SC, stated that DDA 645X1s use the 64531 CDCs for their initial training. PCs are used to present text from the CDCs to the trainees. The PC is also used as a tool to pre-test the trainees before taking the end-of-course test (64).

Mrs. Snook indicated that the Materiel, Storage and Distribution Branch did develop their own training program for the DDA 645X1s. Upon arrival, the trainees are rotated through each of the five sections in the branch, spending one week in each section, before being assigned to a duty section. Each section supervisor has a written training

plan which identifies the key areas in which the trainee should receive training (64).

CMSgt David Reeves, Supply Training Division, Headquarters Material Airlift Command (MAC), stated that his division developed and updated slide/audio training presentations in all areas of initial supply training since 1985, including warehouse location and storage procedures. These programs ran for a duration of 30-45 minutes. They were distributed to all base level training sections throughout MAC. These programs were used in conjunction with CDCs and OJT to train newly assigned personnel (59).

In September 1989, funding and manpower cuts forced the division to stop development and updates of the training slide programs. Base level training sections were directed to use the programs until they became obsolete due to new procedure implementation and/or manual changes. When the programs are no longer useful, new DDA 645X1s will be trained using the 64531 CDCs and OJT (59).

SSgt Chester Miloisock, NCOIC Base Supply Training Section, Scott AFB, Illinois, commented that primary training for DDA 645X1s is accomplished by using the 64531 CDCs and OJT. He said a PC is used for administering the Volume Review Exercises in preparation for end-of-course tests (50).

Investigative Question #2

Do the 645X0 experimental subjects represent a statistically similar population compared to newly assigned DDA 645X1s (i.e. are the means of their AQE scores in the general category similar)?

Before applying any statistical tests, the AQE scores of the entire sample of test subjects (AFSC 645X0) must be compared to AQE scores taken from the 645X1 population. This is done to ensure that the two populations are not significantly different from one another.

AQE scores for the period of 1 Jan 89-31 Dec 89 were obtained from the HRLDB. A total of 439 DDA 645X1 personnel took the AQE test during the time period of 1 Jan 89-31 Dec 89. In order to determine the sample size required for a 95% confidence level, the sample size formula cited in Chapter III was used. The variables in the formula were set as follows; N=439, p=.50, d=.05, and z=1.96. The calculation indicated that a total sample size of 206 was required. A random sample of 206 scores was selected from the 439 645X1 AQE scores, and compared to the AQE scores of the 49 experimental subjects. In order to determine if parametric tests could be used for this comparison of the AQE scores, the assumptions that the samples are normally distributed, and equality of variances had to be tested.

To satisfy the requirement that the samples are normally distributed the Central Limit Theorem was imposed.

Since there were 49 subjects, and the 645X1 sample size was 206, both samples met the generally accepted sample size of 30 in order to impose the CLT. Therefore, the samples have satisfied the assumption of being normally distributed.

Next, the samples were tested for equality of variance using Bartlett's Test of Equal Variances. The null hypothesis that the variances of the two samples are equal was rejected (P value=0.0319) at a .05 significance level.

Since the samples were each found to be normally distributed, but had unequal variances, the assumptions required for the use of parametric tests were not satisfied. Therefore, to determine if there is a difference in AQE general scores for the experimental subjects and DDA 645X1s, the non-parametric, Mann-Whitney U Test was used.

Using the Mann-Whitney U Test for the comparison of AQE scores of the two samples, a P value=0.7189 is obtained. Therefore, at a .05 significance level, the conclusion is not to reject the null hypothesis; there is no significant difference in the AQE scores of the two samples. The statistical tests used to analyze this investigative question can be found on page 132, Appendix G.

Investigative Question #3

Are there any significant differences between the test subjects' AQE scores from the three experimental treatments?

The AQE scores in the general category were used as the criteria to stratify the treatments. Stratification ensures

that the test subjects are represented proportionately in each of the three samples.

Using the K-W ANOVA test and a .05 significance level, no significant differences were found between the test scores in any of the three treatments (P Value=.7181). The statistical test used to analyze this investigative question can be found on page 133, Appendix G. Table 1 contains the AQE scores for the test subjects in each treatment.

Investigative Question #4

Do the test subjects learn more when trained using CBT?

Using the K-W ANOVA test to make the over-all comparisons of the post-test scores, the null hypothesis was rejected (P Value=.0000). Therefore, there is a highly significant difference between one or more of the treatments' post-test scores: CBT=75.6, Text=54, Control=32.2.

The Mann-Whitney U test, a two-sample test, was used to identify where the significant difference(s) were. First, the post-test scores between the text treatment and the CBT treatment were compared using a .05 significance level. This test identified the existence of a highly significant difference (P Value=.0006). Second, the post-test scores between the text treatment and the control group were compared using the same significance level, and a highly significant difference between these treatments was identified (P Value=.0001). Finally, the CBT treatment was compared to the control group and, again, a highly

significant difference between these treatments was identified (P Value=.0000). The statistical tests used to analyze this investigative question can be found on pages 134-135, Appendix G. Table 1 contains the post-test scores for the test subjects in each of the three treatments.

TABLE 1

POST-TEST SCORES, TASK ANALYSIS SCORES, AQE SCORES, AND DESCRIPTIVE STATISTICS

Text Treatment			CBT Treatment			Control Group		
Test	Task	AQE	Test	Task	AQE	Test	Task	AQE
38	0	55	77	80	74	27	0	48
46	40	64	85	40	80	42	0	59
62	60	84	45	60	48	25	0	53
69	70	68	77	80	42	42	0	57
50	0	37	69	50	62	42	0	62
42	10	55	69	70	33	18	0	55
36	60	57	100	30	53	25	0	62
42	10	70	92	70	94	42	0	64
62	60	78	92	80	50	18	0	92
85	70	99	46	80	74	42	0	55
62	70	66	46	20	72	33	10	52
42	20	44	92	60	62	33	0	62
62	20	72	92	70	68	25	0	52
46	0	48	85	90	59	42	0	42
50	0	55	69	90	50	27	0	36
62	70	46	64	80	42	--	--	--
62	30	42	85	90	36	--	--	--
mean								
54.0	34.7	61.2	75.6	67.1	58.9	32.2	0.7	56.7
standard deviation								
13.1	29.0	16.4	17.5	21.1	16.7	9.2	2.6	12.5
median								
50	30	57	77	70	59	33	0	55
minimum								
36	0	37	45	20	33	18	0	36
maximum								
85	70	99	100	90	94	42	10	92

Investigative Question #5

Do the test subjects perform the task analysis better when trained using CBT?

Using the K-W ANOVA test on the task analysis scores at the .05 level, a highly significant difference was identified between the task analysis scores of one or more of the treatments (P Value=.0000). Next, the Mann-Whitney U test was used to identify which treatments were significantly different. Comparing the text treatment to the CBT treatment produced a highly significant difference (P Value=.0012). Comparisons of the text treatment to the control group (P Value=.0004) and the CBT treatment to the control group (P Value=.0000) also identified highly significant differences at the .05 level. The statistical tests used for this investigative question can be found on pages 136-137, Appendix G. Table 1 also contains the task analysis scores for the test subjects in each of the three treatments.

Investigative Question #6

When the test subjects were trained using CBT, was the training time reduced?

Since the control group did not receive any training, the Mann-Whitney U test was used to see if a significant difference existed between the CBT treatment and the Text treatment. This test clearly shows that a highly significant difference does exist between these two

treatments (P Value=.0010) at the .05 level. The statistical test used to analyze this investigative question can be found on page 138, Appendix G. Table 2 contains the training times for the test subjects in the CBT and Text treatments.

TABLE 2

TRAINING MODULE TIMES, POST-TEST TIMES, TASK ANALYSIS TIMES (MINS), AND DESCRIPTIVE STATISTICS

Text Treatment			CBT Treatment			Control Group		
Trng	Test	Task	Trng	Test	Task	Trng	Test	Task
75	14	4	69	13	3	--	17	4
62	12	2	60	11	7	--	13	3
85	14	3	74	15	4	--	18	2
65	9	2	52	14	2	--	15	4
81	19	5	74	12	3	--	15	2
77	14	8	50	11	4	--	16	2
82	16	5	61	14	6	--	15	2
82	17	7	60	13	3	--	6	2
59	14	6	70	10	4	--	9	5
55	8	3	50	7	4	--	14	3
90	18	4	65	10	4	--	10	7
96	9	3	40	7	4	--	16	10
89	8	10	63	7	6	--	8	5
89	13	5	82	11	10	--	10	5
106	14	5	76	13	14	--	13	5
104	8	7	63	10	10	--	--	--
87	12	5	69	13	10	--	--	--
mean								
81.4	12.9	4.9	63.4	11.2	5.8	--	13.5	4.4
standard deviation								
14.7	3.5	2.2	10.9	2.5	3.3	--	3.4	2.7
median								
82	14	5	63	11	4	--	15	4
minimum								
55	8	2	40	7	2	--	6	2
maximum								
106	19	10	82	15	14	--	18	10

Investigative Question #7

Does computer experience and education affect the student's comprehension of material presented via CBT?

The next section, a demographic analysis, will be used to answer this investigative question. The statistical tests used to analyze this investigative question can be found on pages 139-140, Appendix G.

Demographic Analysis of Experimental Subjects

Using the questionnaire, personal information was obtained from all test subjects. This section describes the results of this information. This information helps provide an insight into the characteristics of the test subjects used in this experiment, and may provide an insight into the characteristics of individuals entering the supply career field. The compiled results of the questions contained on the questionnaire are provided in the following discussion.

Figure 18 shows that 57% of the test subjects were male and 43% were female.

	Male	Female
What is your sex?	28	21

Figure 18. Demographics: Sex

Figure 19 shows that more than 55% of the test subjects were either 18 or 19 years of age, and more than 24% of the subjects were either 20 or 21 years of age. Therefore, the

vast majority of the test subjects (79%) range from 18-21 years of age.

What is your age?

18 or less	18-19	20-21	22-23	24-25	26 or over
0	27	12	5	3	2

Figure 19. Demographics: Age

Figure 20 describes the educational level of the test subjects. Over 44% of the test subjects had at least some college.

Figure 21 illustrates that a large majority of the test subjects (82%) had some experience using computers. Another interesting point brought out by the questionnaire is that of the subjects with computer experience, over 20% had more than 3 years of computer experience. The next section in Data Analysis will determine if subjects with computer experience did better in the experimental measurements.

What is your highest educational level?

Non-High School Grad	High School Grad
0	27
Less than 2 yrs. College	**Associates Degree**
16	3
Bachelors Degree	**Masters Degree**
3	0

Figure 20. Demographics: Educational Level

Do you have any computer experience?

Yes	No
40	9

How long have you been using computers?

Less than 6 mos.	6 mos.->1 yr.	1 yr.->2 yrs.	2 yrs.->3 yrs.	More than 3 yrs.
15	6	5	4	10

Figure 21. Demographics: Computer Experience

Figure 22 shows that of those subjects indicating they had computer experience over 62% have some programming experience.

Effect of Education and Computer Experience. In order to determine whether the degree of education or computer experience had an effect on the test subjects' performance

Do you have any programming experience?

Yes	No
25	15

Figure 22. Demographics: Programming Experience

on the experimental measurements in the CBT group, the Mann-Whitney U test was used. To determine the education effect, test subjects were divided into two groups according to their responses on the questionnaire. The first group consists of the test subjects whose highest educational level was a high school diploma, the next group consists of those who had at least some college experience. The Mann-

Whitney U test showed that there was no significant difference (P Value=0.4510) between the test scores of the high school graduates and those having at least some college education at the .05 significance level. The Mann-Whitney U test also showed there was no significant difference between the task analysis scores of the test subjects with a high school education and those with college experience (P Value = 0.3657) at the .05 significance level.

Next, the test subjects were separated into groups of those with six months or less computer experience, and those with more than six months of computer experience. The Mann-Whitney U test showed that there was no significant difference between the group's test scores and task analysis scores (P Values=0.9616 and 0.4705 respectively) at the .05 significance level.

Summary of Demographic Analysis. The results of the demographic analysis indicate that on the average, test subjects were relatively young and well educated, over 40% of whom had some college experience and all had at least a high school diploma. Most of the test subjects had some experience using computers; many with over 2 years of experience. It does not appear as if education level or prior computer experience had an effect on the amount of learning by the CBT test subjects.

Summary of Data Analysis

This chapter provides the answers to the seven investigative questions which were originally posed in Chapter I. This summary attempts to encapsulate the experimental results in a logical and cohesive manner.

Since the termination of the initial 645X1 training course at Lowry AFB, most Base Supply Squadrons have not been provided any strict guidance on how to train their DDA supply warehousemen. Many squadrons are relying on the 64531 CDCs to fill the training void, and some bases have made some efforts to expand 645X1 training. For example, Myrtle Beach AFB has developed a training program for their new DDA 645X1s, where the trainees spend one week in each of the five sections in the Materiel, Storage and Distribution Branch before being assigned to a permanent section. HQ MAC distributed training slide/audio training programs throughout the command, but these programs are rapidly becoming obsolete.

The data collected from the HRLDB showed that there is not a statistically significant difference in the AQE scores in the general category for new 645X1s and the 645X0s, who were used as the experimental subjects. Therefore, based on the selection criteria of using AQE scores in the general category, the population of 645X1s and 645X0s used as experimental subjects are not significantly different than the actual population of 645X1s.

Statistical analysis has shown that all of the subjects in the three experimental treatments are similar (i.e. not significantly different). Therefore, the three treatments are "balanced"; meaning that they are represented equitably in terms of AQE score distribution.

The post-test scores for the CBT and Text treatments were significantly different from one another, with the mean score for the CBT treatment being 21.6 points higher than the mean score of the text treatment. Also, the task analysis scores for the test subjects in the CBT and Text treatments were significantly different from one another, with the mean score for the CBT treatment being 32.4 points higher than the Text treatment. Further, the training times for the test subjects in the CBT and Text treatments were significantly different from one another, with the mean time for the CBT treatment being 18.0 minutes shorter than that of the Text treatment.

The analysis of the effect of computer experience and educational level of the subjects in the CBT group revealed that a higher level of education and\or computer experience does not necessarily enable the test subjects to perform better on either the post-test or task analysis.

V. Conclusions, Recommendations, and Summary

Introduction

Current literature clearly supports the hypothesis that CBT is an effective training technique or tool. However, the development of CBT in the Air Force supply community is only in its infancy, and most of those involved in the process have little or no experience developing CBT. Therefore, it is important to determine the effectiveness of the relatively new Air Force Supply CBT development program before making any long-term commitments towards CBT development.

In order to clearly determine the effectiveness of the CBT development program, as well as to address this study's research hypothesis, this chapter will state the final conclusion for each investigative question. Also, some recommendations for further research in the CBT arena are proposed, some lessons learned are discussed, and a summary of the research methodology and the experimental results are provided.

Conclusions

This research led to some very interesting and very significant results which strongly support the use of CBT. Each investigative question is addressed in order.

Investigative Question #1. What are the current base level training methods for DDA supply warehousemen, AFSC 645X1?

For the most part, the Air Force is primarily using the 64531 CDC to train DDA warehousemen. Although some bases surveyed have developed alternate training methods, most rely solely on the CDC. Also, it is apparent that no efforts have been made higher than base level, to develop a standardized training program for DDA 645X1s.

Investigative Question #2. Do the 645X0 experimental subjects represent a statistically similar population compared to newly assigned DDA 645X1s (i.e. are the means of their AQE scores in the general category similar)?

645X0s do not represent a statistically different population than 645X1s, in terms of their AQE score in the general category. The results of this analysis were clearly significant at a .05 level of significance. Therefore, it is safe to assume that the results of this experiment would not be significantly different had the test subjects actually been DDA 645X1s.

Investigative Question #3. Are there any significant differences between the test subjects' AQE scores in the three experimental treatments?

At the .05 level of significance, the K-W ANOVA clearly showed that there are no significant differences between any of the three experimental treatments. Therefore, it is safe

to assume that the three treatments are representative of the same population.

Investigative Question #4. Do the test subjects learn more when trained using CBT versus CDCs?

The test subjects in the CBT treatment learned significantly more than the test subjects in the text treatment as measured by the post-test with the CBT, Text, and Control groups achieving mean scores of 75.6, 54.0, and 32.2 respectively. The results of the statistical analysis were significant at a .01 level of significance. Therefore, CBT can significantly improve the amount of learning which occurs, when compared to text (CDC) training.

Investigative Question #5. Do the test subjects perform the actual task better when trained using CBT?

At a .01 level of significance, the test subjects in the CBT treatment (mean score=67.1) performed significantly better on the task analysis than did the test subjects in the text treatment (mean score=34.7). Therefore, it is concluded that CBT can significantly improve the ability of trainees to perform the tasks for which they are trained.

Investigative Question #6. When the test subjects were trained using CBT, was training time reduced?

A comparison of the CBT and text treatments at a .01 level of significance, showed that CBT (mean time=63.4 mins.) can significantly reduce the amount of time required

for training versus the text treatment (mean time=81.4 mins.).

Investigative Question #7. Does computer experience and education level affect the student's comprehension of material presented via CBT?

At a .05 level of significance, the test subjects in the CBT treatment did not score significantly different on the post-test or the on the task analysis, regardless of their level of education. Also, prior computer experience did not significantly improve the post-test or task scores of the test subjects in the CBT treatment.

Practical Significance. Practical significance refers to the ease with which one can scan the data and identify obvious differences. For a manager, the practical significance of the data can provide an idea of the magnitude of the results, in terms which are more easily understood. In terms of their practical significance, the data in three particular areas tends to stand out from the rest of the data.

1. The mean training time for the CBT treatment was approximately 63 minutes, compared to 81 minutes for the text treatment. On the average, the test subjects in the CBT treatment completed their training 22% faster than did the test subjects in the text treatment.

2. The mean post-test scores for the CBT and text treatments were approximately 76 and 54 respectively.

Therefore, the test subjects in the CBT treatment scored 28% higher, on average, than those in the text treatment.

3. The mean task analysis scores for the CBT and text treatments were approximately 67 and 34 respectively. As a result, the average CBT test subject was able to accomplish almost 7 of the required steps in the task analysis compared to the less than 3.5 correct steps performed by the average test subject in the text treatment.

Recommendations for Future Research

The number of potential studies which could be performed in the area of CBT is limited only by one's own imagination. Since this study and others have shown that CBT is an effective training technique, there should be additional research efforts to determine which elements of CBT have the greatest impact on the test subjects' rate of learning. For example, what effect does varying factors such as screen design, layout, use of graphics, program interaction, remediation, etc. have on the amount of learning accomplished by the test subjects? Research such as this can help identify which combinations of features work well together to enhance learning.

Another potential area for future research would be to compare the effectiveness of CBT modules to actual classroom lectures or other training techniques. This could be done using a methodology similar to the one used for this study. Research such as this could be used to support the

elimination of technical training courses, or to support the integration of CBT modules into existing technical training courses.

After the CBT modules, which were developed by the office at Lowry AFB, are used in the field for at least six months, a survey should be conducted to examine the impact that CBT has had on improving the knowledge and skills of DDA supply warehousemen. A study such as this, when coupled with this research, could provide some valuable new information about the long-term effects of CBT.

Experimental Logistics Lessons Learned

In order for the experiment to be successful, detailed advanced planning and support was required from several organizations. The most critical organizations providing support were the 3440th TTC, and the AFLMC. This section describes the support these organizations provided and lessons learned in the planning and implementation of this study.

3440th TTC Support. The 3440th provided pre-trip coordination with agencies located at Lowry AFB. Capt Brown, the 3440th POC provided exceptional support at Lowry AFB. Without his assistance, this experiment would have been much more difficult, if not impossible, to complete.
Coordination with four base organizations was required prior to arrival at Lowry AFB: the 3440th Computer Support Section, 3440th Student Training Squadron, Lowry AFB Supply

Squadron, and CBPO Outbound Assignments Section. Capt Brown coordinated closely with these organizations at least one week before the authors' site visit to Lowry AFB.

Even with Capt Brown's prior coordination, some minor scheduling problems did occur. However, most of the problems were fairly easily overcome, and the resultant support provided by the 3440th TTC and the other Lowry AFB organizations was superb and greatly contributed to the success of this study.

AFLMC Support. The primary support required from the AFLMC was to provide the CBT lesson and post-test for the experiment. AFLMC authored the CBT which s used in this experiment. The CBT lesson needed to be transferred from the MERLIN authoring language to the QUEST authoring system prior to release. The transfer and programming of the lesson was accomplished at AFLMC from Dec 89- Mar 90 by Capt Geasey.

When the original program was received on 15 Mar 90, several problems with the program were encountered. The two major problems consisted of program loading difficulties and an incorrect coding of a question in the post-test. The loading problems were a result of the software configuration. In order for the program to load properly the authors were required to edit some of the configuration files in the program. The error in the post-test question was a result of Capt Geasey, who had no supply experience or

training, incorrectly linking an incorrect response as the correct response for question number eight of the post-test. AFLMC was contacted about the problems with the lesson and took corrective actions.

A corrected lesson/test was received from AFLMC on 10 May 90, just days prior to the first planned trip to Lowry AFB. The updated version corrected many of the problems encountered in the initial software. However, additional editing of the program files was still required in order to bring about proper program loading.

With the exception of the program loading problems encountered with the CBT program, overall support provided by the AFLMC was good. Guidance from Lt Col Peterson and the additional temporary duty (TDY) funding provided proved to be invaluable to this research effort.

Summary of Lessons Learned. There were two areas concerned with carrying out this research that could have been improved.

First, the coordination with Lowry AFB organizations could have been improved. If the authors could have traveled to Lowry AFB prior to the experimental trips, to personally explain the intricacies of the experiment with the organizations involved, most scheduling problems and misunderstandings could have been avoided. Unfortunately, funding was not available to take a pre-experimental trip.

Second, some of the computer software problems encountered could have been avoided if the programmer had some experience in the subject area of the CBT lesson, or if the subject matter expert was at the same location. Also, the loading problems could have been avoided if AFLMC had tested the loading of the program on hardware comparable to hardware found at base level prior to forwarding the program to the authors.

Summary

Now is the time to plan for the future of CBT development in the supply career field and in the Air Force. This study has clearly shown that CBT is more effective than CDCs for training new supply warehousemen, AFSC 645X1. When used properly, CBT can decrease the amount of time spent on training while simultaneously increasing learning and the ability of trainees to perform the tasks for which they have been trained.

The Air Force supply community cannot accept the current situation of CBT development because the future will present an ever increasing demand for better, more effective training techniques. A plan needs to be developed now, and the resources must be programmed to ensure that the capacity exists to handle the future demand.

The senior leadership within the Air Force must be made aware of the tremendous positive impact which CBT can have on the workforce, and should act swiftly to develop policy

and guidance. The sooner policy is established, the sooner the Air Force can exploit the existing technology and develop training systems which improve the capacity of our workforce to learn, as well as their capacity to perform.

Appendix A: Article on Air Force CBT Development

THE WAREHOUSE INSTRUCTIONAL WIZARD: THE APPLICATION OF COGNITIVE LEARNING THEORIES TO COMPUTER-BASED TRAINING

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Abstract

This paper examines the application of cognitive science findings to an United States Air Force technical training class using computer-based training (CBT). The CBT being designed and developed is for the material storage and distribution (MS&D) career field. Initial technical training for al MS&D specialists will be conducted through the use of these computer-based training modules and on-the-job experience.

Introduction

Performance occurs when an individual translates internally stored knowledge into specific behaviors of cognitive processes. For example, an aircraft mechanic demonstrates the application of stored knowledge to a specific behavior when (s)he repairs a malfunctioning leading edge flap on a fighter aircraft. Likewise, when a computer programmer conceptualizes the design for a new inventory control program, (s)he is demonstrating the application of stored knowledge to a cognitive process.

To perform any mental or physical task requires stored knowledge. Stored knowledge is acquired through the learning process. Learning is defined as the acquisition of knowledge which causes a relatively permanent change in specific behaviors or cognitive processes. As Norman (1982) points out, learning is more than just remembering. It is also the ability to perform some task with skill. Learning then is both purposeful remembering and skillful performance. Learning can occur in many different ways. For example, learning can occur through trial and error, imitation, or a conscious effort to master some body of knowledge. The latter form of learning, when intended to provide domain-specific knowledge, is referred to as technical training.

Currently, most of the technical training conducted in the United States Air Force is rooted in the behavioralist traditions of B. F. Skinner (1971). The central theme of Skinner's work is that human behaviors are controlled by the immediate consequences following those behaviors. So behaviors which are immediately reinforced will be repeated, and behaviors which are not immediately reinforced will not be repeated. The application of Skinner's operant conditioning principles through the use of programmed instruction has consistently shown a reduction in the amount of time required to train a specific technical skill (Mayo, 1969).

On the other hand, the programmed instruction method does not seem to improve the acquisition of knowledge or the retention of knowledge over time (Wexley & Latham, 1981). One explanation for these results is that when educators operationalize the operant conditioning principles, the trainee generally is relegated to the role of passive receiver and transmitter. Another explanation is that in an effort to construct strong learning-knowledge-reward relationships, trainers simplify the learning so much that the learning becomes trivial. The insignificance of the learning may also explain why training times are always lower using programmed instruction techniques. The end results are these: 1) training becomes linear and sequential in nature, 2) seldom is the training internalized or integrated with other knowledge, and 3) the learning which does take place is generally only measurable by paper and pencil tests rather than actual performance of the specific task.

With the emergence of cognitive psychology as a science over the past thirty years, the role of the trainee as a passive receiver of information has changed. More and more cognitive scientists (Anderson, 1980; Anderson, 1981; Lindsay & Norman, 1977 Norman, 1982) are arguing convincingly that learners are active information processors, deciding what information is important, how to organize that information, how to store that information

internally, and how (or even if) to use that information in different situations. The research on cognitive information processing has led to new learning theories and methods.

New cognitive learning theories promote the concept of cognitive model development. A cognitive model for a specific task is an individual's mental representation of the task. In other words, this mental model consists of specific facts or principles about the task (declarative knowledge), how the task is best accomplished (procedural knowledge), and information about how this task fits into other tasks (system knowledge). All of this information is integrated into an organized structure often referred to as a schematic net. People use these cognitive models to interpret environmental cues and to decide how to respond to these cues. When a cognitive model is tightly integrated for a domain-specific task, the individual is said to have compiled knowledge. Generally, other people refer to this person as an expert.

The complexity that cognitive models add to training domain-specific technical tasks is enormous. For that reason, few practical applications of cognitive learning theories have emerged. Yet the benefits which can be realized are also enormous. On the other hand, to institute this form of training in a classroom environment would mean substantially extending the length of most resident courses (Bourne, Dominowski, Loftus, & Healy, 1986). The desire of

most organizations (including the Air Force) to reduce classroom time and move the training closer to the actual work environment, makes the use of cognitive learning theories very unlikely.

However, by combining the new cognitive learning theories with computer-based technology it is possible to improve the learning and to reduce training time simultaneously. Ferguson (1989) refers to this integration of new instructional technology and cognitive learning theories as a student-centered approach versus an instructor-centered approach to technical training. In addition, the ability to export computer-based courseware to the actual work site has the potential of reducing classroom time and of moving the training directly into the work environment. While these benefits seem possible, few applications have yet emerged.

This is the central issue of this manuscript: the implications of applying cognitive learning theories to computer-based training for a specific technical skill. Specifically, the technical skill under development is the material, storage and distribution specialty (i.e. warehousing skills). In the remainder of this manuscript, I will discuss cognitive learning principles as they apply to developing a mental model for the design and development of computer-based training for the warehousing task. Specific cognitive learning theories will be discussed as they

apply to tutoring, practice, and mastery for the warehousing task.

Mental Models

A mental model for any task or activity is an individual's conceptualization of the work domain (environmental situation), the applicable task knowledge (declarative knowledge), and how to apply that knowledge to the specific task (procedural knowledge). According to Gott, Bennett, and Gillet (1986), mental models serve as road maps for problem solving activities. These models influence what information is acquired from a problem-solving event, how problems are represented in an individual's memory, and how new information about a specific problem is organized and accessed later when a similar work setting presents itself. Rummelhart and Norman (1981) found that in learning problem-solving skills, the majority of errors can be traced to faulty mental models. A good mental model allows an individual to predict the effects of his/her actions. Norman (1988) argues that without a good mental model we operate by rote memory - only doing what we are told to do, but not understanding why or being able to explain to others the effects of our efforts. Norman says working without a mental model works fine as long as nothing goes wrong; but when something does go wrong or when we are faced with a novel situation, we are stymied

because we do not have a deeper mental model for the given task.

While mental models serve a critical function in an individual's development of technical competency, only recently have learning theorists started to empirically study how these models are developed. For example, Gott, Bennet, & Gillet (1986) found that greater success in converging on the source of electronic system malfunction was partially explained by the superior mental models possessed by the skilled electronics technicians versus the less-skilled technicians. This research confirms the importance of developing mental models as part of the technical training. Gagne and Classner (1987) suggest that one tactic for doing this is to attach the new mental model to everyday situations or similar phenomena the trainee has already experienced.

In the material, storage and distribution course, we applied this principle by creating two separate lessons. The first was a lesson on the overall Air Force Supply System. In this lesson, we relate Supply to Sears, Wal-Mart, 7-11 Stores, and Texaco. Throughout this lesson, the MS&D trainee is provided familiar mental models and then those models are related to the Air Force Supply System. The objective here is not to introduce the trainee to new terminology or specific procedures, but to develop the skeleton of a mental model of the supply system. In the

second lesson, we focus in on the material, storage and distribution function. In this lesson, we use examples from Sears again, but also mini-storage facilities, K-Mart distribution centers, and delivery services. Upon completion of these two lessons, the MS&D trainees have a reasonably good mental framework upon which to build. Mager (1988) describes this as providing the student with the big picture or a mental framework upon which to store other knowledge. Based on this framework, Mager (1988) argues that performance objectives can be generated for specific tasks the trainee needs to perform.

Performance Hierarchies

Performance objectives are word descriptions of the performance a trainee needs to exhibit before (s)he is considered competent. In the MS&D course, each task was defined by a performance objective. For example, being able to store property with an assigned warehouse location, being able to process organizational refusals, being able to perform a bench stock inventory, being able to input receiving documents to the base supply computer system are all examples of performance objectives. These objectives each identify the intended result of the lesson, rather than the process of the instruction. In addition, each of these performance objectives focuses on what the trainee must do to demonstrate competence. From the performance objectives, performance hierarchies are created. A performance

hierarchy is a graphical representation of the knowledge clusters needed to perform the stated objective. Mager (1984) argues that performance hierarchies help the instructional developer answer the question "what does the trainee need to know to perform this task?" Performance hierarchies also provide a graphical image of the relationship between different pieces of knowledge. This information aids the instructional developer in determining the sequencing of task information. For every performance objective in the MS&D course, a performance hierarchy was created. One additional benefit of these hierarchies was that 17 repeating knowledge clusters were identified across 90 different performance objectives. These seventeen clusters were combined into separate "principles of warehousing" modules. By reclustering this knowledge into a separate module, this material could be taught as propaedeutic skills to all MS&D specialists early in their training program. These learning theory principles were applied to all lessons to ensure that all lessons were structures around optimal mental model development. The performance hierarchies, once created, were then used to design and develop the computer-based tutorial for each hierarchy.

Tutorial

Each performance objective has a tutorial which is self-paced and is individualized to the trainees based on

their responses to memory check items throughout the tutorial. Criswell (1989) calls this form of tutorial a "branching program" which adapts to the individual trainee as the material is presented. In a branching tutorial, time and content vary according to the trainee's needs. This is consistent with Reynolds (1987), who says a good computer-based tutorial lesson advances just like a good human tutor would, based on the interaction between the tutor and the student. Fitts and Posner (1967) refer to this as the cognitive stage of learning during which a trainee forms a mental representation of how a skill is performed.

In addition, the self-paced and individualize nature of the computer-based lesson is consistent with what we know about adult learners. Knowles (1979) reports that adult learners vary in their rate of learning, that they enter the learning situation with varying degrees of experience, and that they have different learning styles and preferences. With these factors in mind, it seems that the optimal learning strategy would be to have the training system adapt to the learner's past experience, knowledge, and current needs. In an effort to integrate these concepts into the MS&D courseware, another form of adaptive training is capitalized on. When knowledge from one of the earlier lessons was needed in a later lesson, the trainee was given a short pre-test (consisting of three questions) on the principle in question. Based on answer analysis of the pre-

test, the current computer-based lesson determines the amount of refresher training necessary. The refresher training could consist of no additional training at all if the trainee got all of the questions right. On the other hand, if the trainee missed only the hard question, the refresher training may be a one screen summary of the information. Complete retraining of the principle might automatically occur given that the trainee missed all three questions.

All of the tutorial lessons adapt according to the responses of the trainees. Based on the response of a trainee to a memory check item, the computer-based lesson analyzes the response and provides the trainee with either positive feedback or tailored remediation for each of the other responses. The positive feedback not only tells the trainee that the correct answer has been chosen, but also provides expanded information on the topic. These positive feedback blocks are also color coded on the computer screen to send a positive visual display to the trainee. The remediation feedback blocks are each tailored to the specific response item chosen. In this way, the specific error made is remediated and the correct information reinforced. Just as the positive feedback blocks are color coded, so are the remediation blocks, but with a different color.

Each tutorial lesson also starts with information on how this specific performance objective fits into the mental framework created in the first two lessons of this course. It also explains why this material is important to understanding the performance task at hand. MacLachlan (1986) reports that explaining the benefit of a tutorial lesson increases a trainee's attention. By increasing a trainee's attention level, we also increase the likelihood that more information will be retained by the trainee (Criswell, 1989).

To aid the trainee in organizing the information, all learning clusters or segments within a lesson start with an advance organizer. An advanced organizer aids a trainee like a road map aids a traveler. It provides an overview of how this information relates to the overall performance objective. It can also show how past knowledge clusters are related to this objective and how this task fits into the larger performance framework. In many ways, an advanced organizer helps prepare the trainee for the learning process. By providing an advanced organizer, the trainee has a knowledge skeleton upon which to build. Clark (1987) argues that providing an advanced organizer increases the attention level of the trainee, provides the trainee with a structure upon which to hang other details, and aids the trainee with the management of the learning process.

In addition, each learning cluster is concluded with a summary of the essential information in that segment. Once again, Clark (1987) argues that the summary provides the trainee the opportunity to reexamine his/her own knowledge structure to ensure that the essential information has been stored.

Practice

In addition to the tutorial for each performance objective, each objective also has a practice component which follows the tutorial. Salisbury (1988) posits that, no matter how effective the initial tutorial is, unless the trainee is allowed sufficient time to practice, (s)he may never demonstrate mastery of the task. The practice component allows the trainee to apply the knowledge (s)he just learned in the tutorial. Fitts and Posner (1967) call this "the associative stage of learning." Here the trainee attempts to perform the task using the knowledge acquired in the cognitive stage (tutorial). Usually errors or misunderstandings are identified during the early practice sessions. With remediation and more practice, execution of the skill is improved until the trainee performs the task effortlessly and without assistance from the computer. In some ways, computer-based practice is like walking a tightrope with a safety net.

Each practice session is scenario-based. The trainee is presented with a specific work setting and then is asked to respond to some form of inquiry. Salisbury (1988) calls this type of practice "drills for intellectual skills." In this type of practice, work problems are presented to the trainee and the trainee is asked to solve the problem using prior knowledge. For example, a scenario might read as follows:

> You have just returned from lunch and your supervisor asks you to store the property which was brought over from the Receiving Section. You go out to the holding area and find three items with attached Notices to Stock Documents. The first item's Notice to Stock Document is shown to you on the screen. Will you store this piece of property in your warehouse?

Based on the answers to this scenario, the computer-based practice component will determine if and how much additional training is necessary on this concept. Based on the answer analysis, the practice component will either route the trainee to additional training on this concept or advance to the next scenario. The practice session can be repeated as often as the trainee wishes, allowing the trainee to fine tune the skill and develop confidence in his/her ability.

Mastery

If the practice component is like walking a tightrope with a net, then mastery is like performing the task without a net. Sullivan and Elenburg (1988) call this type of evaluation "performance testing." Performance tests are

based on the performance objective, just as the tutorial and practice components are. The performance test simulates the actual work environment and the work situation that will be experienced in that setting. It provides work situations to the trainee. Based on the trainee's response to these situations, the training system evaluates the trainee's ability to correctly perform the necessary motor or cognitive skill to successfully complete the task. These work setting simulations provide greater realism in the testing environment. The simulation allow the trainee to follow a line of reasoning to its logical conclusion. It should be pointed out that the reasoning may have been flawed early in the simulation, but the computer simulation will allow the trainee to follow that line of reasoning to a logical conclusion. By analyzing the individual responses throughout the simulation, the computer-based performance test provides very valuable information on where the flaw is in the knowledge base and what remediation is necessary to repair the knowledge base.

Computer-based performance tests also allow for adaptive testing techniques (Ward, 1984). Each response can be analyzed and, based on past responses, the most appropriate next question can be asked. For example, in the MS&D mastery component, each trainees response is examined; if the response is determined to be incorrect, another scenario based on the same information is presented to the

trainee. If the trainee performs correctly in the second scenario, (s)he is allowed to pass through the gateway for that knowledge cluster. On the other hand, if the trainee performed incorrectly on the second effort, the computer-based master component notifies the trainee what specific knowledge is deficient and in need of remediation. While there are over thirty different scenarios in the mastery, a skilled trainee will complete mastery by answering only ten scenarios. The other scenarios are needed to refine and identify specific knowledge flaws.

Summary

Based on accepted cognitive learning principles, we know that learners are not passive receptors of information. They are active information processors attending to information which the learner believes will assist him/her in accomplishing a specific task. With this knowledge, we can provide learners with mental models which will assist the learner in the learning process. We know that practice of a skill greatly influences late performance. Through the use of answer analysis and remediation techniques, a learner's skill level can be improved through computer-based practice. Finally, by combining microcomputer power with adaptive testing techniques, we are able to more accurately measure an individual's learning and the specific flaws in that learning.

The following two pages provide a list of the references used in "The Warehouse Instructional Wizard" article (Appendix A).

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Appendix B: Procedures for Determining Treatment Composition

Step 1. Get AQE scores in general category for test subjects from CBPO.

Step 2. Determine treatment composition.

a. Rank students by score on AQE test (highest to lowest).

b. Divide scores into quartiles. If the number of students is evenly divisible by 4, then all quartiles will be of equal size. If the number of students divided by 4 leaves a remainder, then assign the extra student(s):

remainder	quartile(s) assigned
1	1
2	1,2
3	1,2,3

Step 3. Use the random number table to assign the test subjects in each quartile to a treatment.

a. Choose a stream of 2 digit random numbers.

b. Assign test subjects to the treatments in this order: CBT, CDC, Control group

c. Breakpoints are determined by dividing the total number of students in the quartile by 100. For example, if there are 4 students in the quartile, then there will be 4 breakpoints, 00-24, 25-49, 50-74, 75-99.
If the first random number is 24, then student number 1 will be assigned to the CBT treatment. If the second random number is between 00-24, then you must skip this random number and pick again (because 00-24 represents student 1 who has already been assigned to a (treatment).

d. Repeat process for students in other 2 quartiles.

Appendix C: Prepared Introductions for Treatments

A. CBT Treatment

Good afternoon, my name is Capt _______, and I would like to welcome all of you to Lowry AFB. Today you will begin your supply training by using the personal computer to take a supply lesson. Once you have finished the lesson, you will take a test. I am going to give you some specific information which you must understand before we begin, and then I'll answer any questions you may have. It is very important that you pay attention while I am giving you these instructions. If you don't understand any of the instructions, please tell me <u>before</u> we begin the training lesson.

<u>OVRHD</u>-Does your computer show the "C:\QUEST" prompt?
- There is no time limit for you to complete the training. However, you must complete the training material before you can take a break.
- During the training, only one person is permitted to use the restroom at a time.
- If you finish the training lesson early, you must remain seated and quiet until everyone is finished.
- Also, during the break, you <u>are not</u> allowed to discuss any information from the lesson with other airmen.

<u>OVRHD</u>-A few times during the training, you will have the choice to continue on, review material, stop and save your place, or stop without saving your place. When you reach these decision points, feel free to continue or review material: NEVER stop the lesson by pressing "X" or "F10".

<u>OVRHD</u>-During the lesson, if you see a screen that tells you to contact your trainer or your supervisor for help, let me know IMMEDIATELY. I will have to adjust your computer so you can continue.

<u>OVRHD</u>-When you reach the end of the training material, you will answer some practice questions before taking the test. After answering the last practice question, you will see a green box on your screen which says, "Great, you've got the idea. Now you are ready to take the test." When you reach this point, STOP and raise your hand.
I don't want you to go past that screen until everyone is finished with the training.
- Before we begin the test, you will be given a 15 minute break to relax, use the restroom, etc. During the break, you must remain in the break area (or whatever location is assigned).
- Some of you may know a lot about computers, and some of you probably don't know anything. If you are not familiar with computers, don't worry. Once the

training lesson begins, all you have to do is follow the instructions on the computer.

-Before we begin, let me remind you that as members of the United States Air Force, you are bound by a code of honor. Therefore, I expect <u>all</u> of you to follow my instructions carefully.

-During the training, let me know if you are having any problems, or if you have any questions. I will try to answer your questions as best as I can.

Does anyone have any questions before we begin?

<u>OVRHD</u>-Please type the word "CBTEVL and hit the <enter> key.

<u>OVRHD</u>-Remember, don't press "X" or "F10" when given the choice, and when you see the other two statements, STOP and raise your hand.

You may begin.

B. CDC Treatment

Good afternoon, my name is Capt ________, and I would like to welcome all of you to Lowry AFB. Today you will begin your supply training by taking a supply lesson. Once all of you have finished, you will all take a test.

I am going to give you some specific information which you must understand before we begin, and then I'll answer any questions you may have. It is very important that you pay attention while I am giving you these instructions. If you don't understand any of the instructions, please tell me <u>before</u> we begin the training module.

-There is no time limit for you to complete the training. However, you must complete the training material before you can take a break.

-At the end of each section in the training material, there are questions which I encourage you to answer before you continue on. Feel free to write in these booklets.

-During the training, one person is permitted to use the restroom at a time.

-If you finish the training material early, you must remain seated and quiet until everyone is finished.

-After the training module is finished, you will be given a 15 minute break to relax, use the restroom, etc. During the break, you must remain in the break area (or whatever location is assigned).

-Also, during the break, you <u>are not</u> allowed to discuss any information from the training material with other airmen.

Does anyone have any questions at this point?

This training material is self-explanatory. Read the material, and I encourage you to answer the exercise questions before going on. The answers to the exercise questions are in the back of your training package.

Before we begin, let me remind you that as members of the United States Air Force, you are bound by a code of honor. Therefore, I expect <u>all</u> of you to follow my instructions carefully.

During the training, let me know if you are having any problems, or if you have any questions. I will try to answer your questions as best as I can.

Does anyone have any questions? You may begin.

C. Control Group

Good afternoon, my name is Capt _______, and I would like to welcome all of you to Lowry AFB. Today you will use a personal computer to take a test to see how much knowledge you have of some basic supply operations.

I am going to give you some specific information which you must understand before we begin, and then I'll answer any questions you may have. It is very important that you pay attention while I am giving you the instructions. If you don't understand any of the instructions, please tell me <u>before</u> we begin the test.

-there is no time limit on this test.
-raise your hand as soon as you are finished with the test. Afterward, you may go to the break area.
-Once everyone is done, I will bring you back in the room for further instructions.
-during the test and the break, you <u>are not</u> allowed to discuss the test with any other airmen.

<u>OVRHD</u>-does your computer screen show the "C:\QUEST" prompt?
-there are 13 questions on the test.
<u>OVRHD</u>-STOP, raise your hand when you reach the "C:>" prompt.

Does anyone have any questions at this point?

This test is self-explanatory. Follow the instructions on the computer, and answer the questions to the best of your ability.

Before we begin, let me remind you that as members of the United States Air Force, you are bound by a code of

honor. Therefore, I expect <u>all</u> of you to follow my instructions carefully.

During the test, let me know if you are having any problems, or if you have any questions. I will be happy to answer your questions as best as I can.

Does anyone have any questions before we begin?

Remember, read the test questions carefully and answer them as well as you can.

<u>OVRHD</u> Please type the word "PRETEST" and hit the <ENTER> key.

You may begin.

Appendix D: Introduction to Task Analysis

You are assigned to the Storage and Issue section of this supply squadron. This piece of property was delivered to base supply today by a truck. The people in the receiving section of base supply in-processed this piece of property on the computer, and when they did, this piece of paperwork printed out on their printer. Someone from the receiving section brought this piece of property and this paperwork to you. Your job is do whatever is necessary to properly store this property in the warehouse. While you are actually performing this task, you should describe to me what you are doing so that I can understand exactly what you are doing.

Appendix E: Task Evaluation Checklist

TASK EVALUATION CHECKLIST

SUBJECT (Name): Start Time:
Completion Time:

Ask the airman to describe the steps he/she takes to store the property. Put a check in each blank space when the airman correctly completes the indicated step in the property location procedure.

Initial Check of Property and Documentation

1. ______ Is a MGT Notice or a DOR attached to the property?

2. ______ Did the airman determine if the property was forwarded to the correct warehouse?

Finding the Warehouse Location

3. ______ Did the airman determine the correct stockroom from the MGT Notice?

4. ______ Did the airman determine the correct bin row?

5. ______ Did the airman determine the correct horizontal bin location?

6. ______ Did the airman determine the correct vertical bin location?

Storing Property in the Warehouse Location

7. ______ Did the airman correctly compare the Stock Number and Warehouse Location on the MGT Notice with the Bin Label at the Warehouse Location?

8. ______ Did the airman determine if the quantity of the property to be stored agreed with the quantity on line 2 of the MGT Notice?

9. ______ Did the airman compare the Stock Number on the property to be stored with the Stock Number on the property in location?

10. ______ Did the airman sign and date Block 9 of the MGT Notice and distribute the document?

Appendix F: CBT Experimental Subject Questionnaire

Questionnaire

NAME:

This questionnaire is designed to provide us with important information needed for our study. Please write your name in the space provided above. The information you provide will be used only in this study and not for any other purposes in accordance with the USAF Privacy Act.

Please answer the following questions carefully. Circle only one response unless otherwise indicated.

1. Has anyone given you any information about this segment of your training since your arrival at Lowry AFB?

   a. Yes
   b. No

2. What is your sex?

   a. Male
   b. Female

3. What is your age?

   a. Under 18
   b. 18 to 19
   c. 20 to 21
   d. 22 to 23
   e. 24 to 25
   f. 26 or Older

4. What is your highest educational level?

   a. Non-high school graduate
   b. High school graduate or equivalent
   c. Less than two years of college
   d. Associates degree or equivalent
   e. Bachelors degree
   f. Masters degree

5. Do you have any experience using computers?

  a. Yes
  b. No

If you answered yes to the above question continue to the next question. If you answered no to the above question, turn the questionnaire in to your monitor.

6. How long have you been using computers?
  a. 6 months or less
  b. More than 6 months - Less than 1 year
  c. More than 1 year - Less than 2 years
  d. More than 2 years - Less than 3 years
  f. 3 years or more

7. What type of software do you have experience with? (You may circle more than one answer)

  a. Word processing software (i.e. Word Perfect)
  b. Spreadsheet software (i.e. Lotus 1-2-3)
  c. Database software (i.e. dBase III)
  d. Graphics software (i.e. Harvard Graphics)
  e. Game software

8. Do you have any programming experience?

  a. Yes
  b. No

If you answered yes continue to the next question. If you answered no, you are finished with the questionnaire. Please turn the questionnaire into your monitor.

9. What programming language are you familiar with? (You may circle more than one answer)

  a. FORTRAN
  b. BASIC
  c. COBOL
  d. DOS
  e. PASCAL
  f. dBASE
  g. Other

Please turn your questionnaire in to your monitor.

Appendix G: Statistical Computer Output

ONE WAY AOV

VARIABLE	MEAN	SAMPLE SIZE	GROUP VARIANCE
SCOREEXP	58.98	49	231.4
SCON206	59.31	206	145.2
TOTAL	59.24	255	

SOURCE	DF	SS	MS	F	P
BETWEEN	1	4.213	4.213	0.03	0.8718
WITHIN	253	4.087E+04	161.5		
TOTAL	254	4.087E+04			

	CHI SQ	DF	P
BARTLETT'S TEST OF EQUAL VARIANCES	4.60	1	0.0319

COCHRAN'S Q 0.6145
LARGEST VAR / SMALLEST VAR 1.594

COMPONENT OF VARIANCE FOR BETWEEN GROUPS -4.680E-01
EFFECTIVE CELL SIZE 336.2

CASES INCLUDED 255 MISSING CASES 157

RANK SUM TWO SAMPLE TEST FOR SCOREEXP VS SCON206

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
SCOREEXP	6.104E+03	49	4.879E+03	124.6
SCON206	2.654E+04	206	5.214E+03	128.8
TOTAL	3.264E+04	255		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.360
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.7189

CASES INCLUDED 255 MISSING CASES 157

SCOREEXP-AQE SCORES FOR 645X0 EXPERIMENTAL SUBJECTS
SCON206-AQE SCORES FOR RANDOM SAMPLE OF 645X1 PERSONNEL

KRUSKAL-WALLIS ONEWAY NONPARAMETRIC AOV

VARIABLE	MEAN RANK	SAMPLE SIZE
TXTAQE	27.0	17
CBTAQE	24.8	17
CONAQE	22.9	15
TOTAL	25.0	49

KRUSKAL-WALLIS STATISTIC 0.6624
P VALUE, USING CHI-SQUARED APPROXIMATION 0.7181

PARAMETRIC AOV APPLIED TO RANKS

SOURCE	DF	SS	MS	F	P
BETWEEN	2	134.8	67.40	0.32	0.7264
WITHIN	46	9.633E+03	209.4		
TOTAL	48	9.768E+03			

CASES INCLUDED 49 MISSING CASES 2

TXTAQE-AQE SCORES FOR THE TEXT GROUP
CBTAQE-AQE SCORES FOR THE CBT GROUP
CONAQE-AQE SCORES FOR THE CONTROL GROUP

KRUSKAL-WALLIS ONEWAY NONPARAMETRIC AOV

VARIABLE	MEAN RANK	SAMPLE SIZE
TXTTST	25.4	17
CBTTST	38.4	17
CONTST	9.4	15
TOTAL	25.0	49

KRUSKAL-WALLIS STATISTIC	33.2130
P VALUE, USING CHI-SQUARED APPROXIMATION	0.0000

PARAMETRIC AOV APPLIED TO RANKS

SOURCE	DF	SS	MS	F	P
BETWEEN	2	6.710E+03	3.355E+03	51.66	0.0000
WITHIN	46	2.988E+03	64.95		
TOTAL	48	9.698E+03			

CASES INCLUDED 49 MISSING CASES 2

RANK SUM TWO SAMPLE TEST FOR TXTTST VS CBTTST

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
TXTTST	197.0	17	44.00	11.6
CBTTST	398.0	17	245.0	23.4
TOTAL	595.0	34		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION	3.444
TWO TAILED P VALUE FOR NORMAL APPROXIMATION	0.0006

CASES INCLUDED 34 MISSING CASES 0

TXTTST-TEST SCORES FOR THE TEXT GROUP
CBTTST-TEST SCORES FOR THE CBT GROUP
CONTST-TEST SCORES FOR THE CONTROL GROUP

RANK SUM TWO SAMPLE TEST FOR TXTTST VS CONTST

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
TXTTST	387.0	17	234.0	22.8
CONTST	141.0	15	21.00	9.4
TOTAL	528.0	32		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 4.003
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.0001

CASES INCLUDED 32 MISSING CASES 2

RANK SUM TWO SAMPLE TEST FOR CBTTST VS CONTST

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
CBTTST	408.0	17	255.0	24.0
CONTST	120.0	15	0.000	8.0
TOTAL	528.0	32		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 4.796
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.0000

CASES INCLUDED 32 MISSING CASES 2

KRUSKAL-WALLIS ONEWAY NONPARAMETRIC AOV

VARIABLE	MEAN RANK	SAMPLE SIZE
TXTTSK	25.0	17
CBTTSK	38.1	17
CONTSK	10.2	15
TOTAL	25.0	49

KRUSKAL-WALLIS STATISTIC	32.0570
P VALUE, USING CHI-SQUARED APPROXIMATION	0.0000

PARAMETRIC AOV APPLIED TO RANKS

SOURCE	DF	SS	MS	F	P
BETWEEN	2	6.185E+03	3.092E+03	46.25	0.0000
WITHIN	46	3.076E+03	66.87		
TOTAL	48	9.260E+03			

CASES INCLUDED 49 MISSING CASES 2

RANK SUM TWO SAMPLE TEST FOR TXTTSK VS CBTTSK

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
TXTTSK	203.0	17	50.00	11.9
CBTTSK	392.0	17	239.0	23.1
TOTAL	595.0	34		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION	3.238
TWO TAILED P VALUE FOR NORMAL APPROXIMATION	0.0012

CASES INCLUDED 34 MISSING CASES 0

TXTTSK-TASK SCORES FOR THE TEXT GROUP
CBTTSK-TASK SCORES FOR THE CBT GROUP
CONTSK-TASK SCORES FOR THE CONTROL GROUP

RANK SUM TWO SAMPLE TEST FOR TXTTSK VS CONTSK

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
TXTTSK	375.0	17	222.0	22.1
CONTSK	153.0	15	33.00	10.2
TOTAL	528.0	32		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 3.550
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.0004

CASES INCLUDED 32 MISSING CASES 2

RANK SUM TWO SAMPLE TEST FOR CBTTSK VS CONTSK

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
CBTTSK	408.0	17	255.0	24.0
CONTSK	120.0	15	0.000	8.0
TOTAL	528.0	32		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 4.796
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.0000

CASES INCLUDED 32 MISSING CASES 2

RANK SUM TWO SAMPLE TEST FOR TXTRT VS CBTTRT

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
TXTRT	393.5	17	240.5	23.1
CBTTRT	201.5	17	48.50	11.9
TOTAL	595.0	34		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 3.289
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.0010

CASES INCLUDED 34 MISSING CASES 0

TXTRT-TEXT GROUP TRAINING TIME
CBTTRT-CBT GROUP TRAINING TIME

RANK SUM TWO SAMPLE TEST FOR HSED VS COLED

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
HSED	91.00	11	25.00	8.3
COLED	62.00	6	41.00	10.3
TOTAL	153.0	17		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.754
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.4510

CASES INCLUDED 17 MISSING CASES 5

HSED-TEST SCORES FOR HIGH SCHOOL EDUCATION IN CBT GROUP
COLED-TEST SCORES FOR SOME COLLEGE EDUCATION OR ABOVE IN CBT GROUP

RANK SUM TWO SAMPLE TEST FOR HSEDTK VS COLEDTK

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
HSEDTK	108.5	11	42.50	9.9
COLEDTK	44.50	6	23.50	7.4
TOTAL	153.0	17		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.905
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.3657

CASES INCLUDED 17 MISSING CASES 5

HSEDTK-TASK SCORES FOR HIGH SCHOOL EDUCATION IN CBT GROUP
COLEDTK-TASK SCORES FOR SOME COLLEGE EDUCATION OR ABOVE IN CBT GROUP

RANK SUM TWO SAMPLE TEST FOR COMPEX VS NCOMEX

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
COMPEX	73.00	8	37.00	9.1
NCOMEX	80.00	9	35.00	8.9
TOTAL	153.0	17		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.048
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.9616

CASES INCLUDED 17 MISSING CASES 5

COMPEX-TEST SCORES FOR OVER 6 MONTHS OF COMPUTER EXPERIENCE IN CBT GROUP
NCOMEX-TEST SCORES FOR NO OR LESS THAN 6 MONTHS COMPUTER EXPERIENCE IN CBT GROUP

RANK SUM TWO SAMPLE TEST FOR COMPEXK VS NCOMEXK

VARIABLE	RANK SUM	SAMPLE SIZE	U STAT	AVERAGE RANK
COMPEXK	80.00	8	44.00	10.0
NCOMEXK	73.00	9	28.00	8.1
TOTAL	153.0	17		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION 0.722
TWO TAILED P VALUE FOR NORMAL APPROXIMATION 0.4705

CASES INCLUDED 17 MISSING CASES 5

COMPEXK-TASK SCORES FOR OVER 6 MONTHS OF COMPUTER EXPERIENCE IN CBT GROUP
NCOMEXK-TASK SCORES FOR NO OR LESS THAN 6 MONTHS COMPUTER EXPERIENCE IN CBT GROUP

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13. ABSTRACT (*Maximum 200 words*)
Currently, there is no in-residence technical training course for Supply warehousemen, AFSC 645X1. Therefore, base level supervisors and trainers are responsible to provide the initial technical training for direct duty assigned airmen in the 645X1 AFSC. Given the absence of a formal technical training course, most base level supply squadrons use the 64531 Career Development Course (text) to train their direct duty assigned warehousemen. The purpose of this study was to conduct an experiment which compares the effectiveness of Computer-Based Training (CBT) with the commonly used text training, using a CBT module which was developed by the new supply CBT development team, located at Lowry AFB, CO. The results of this study have shown that when used properly, CBT can increase the amount of learning which takes place, increase the ability of trainees to perform the tasks for which they were trained, and reduce total training time. This research directly supports the Air Forces' continued use of CBT for the initial training of supply warehousemen, and further suggests that CBT may be a suitable technique for other Air Force training needs.

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